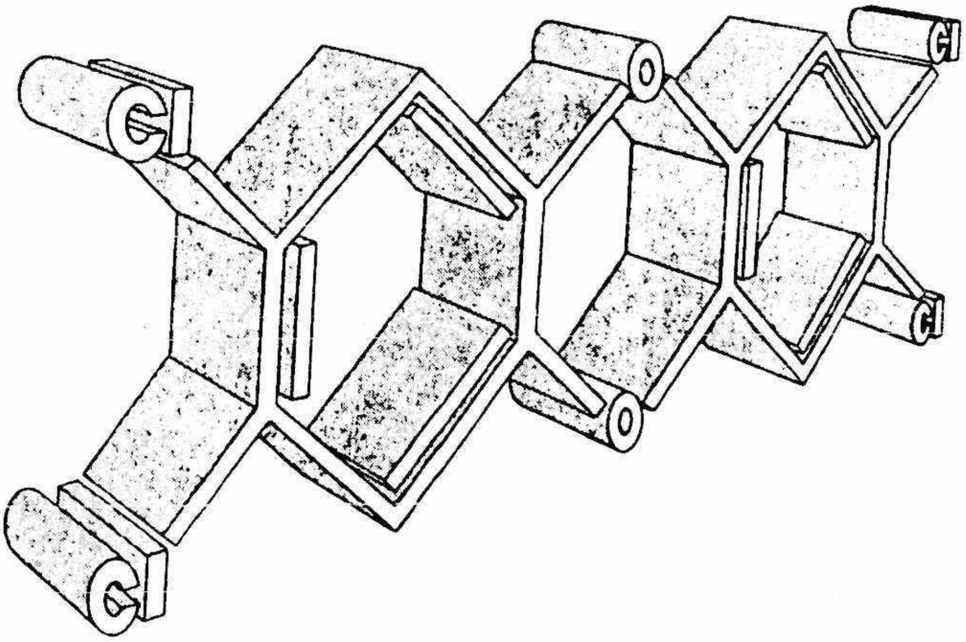
DIOXINS
IN THE ENVIRONMENT
THE INSIDE STORY



Proceedings of
a Seminar on Dioxins and Furans

October 22, 1986
Rexdale, Ontario

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Ministry
of the
Environment

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DIOXINS IN THE ENVIRONMENT: THE INSIDE STORY

A SEMINAR ON DIOXINS AND FURANS

Introduced by: Rod McLeod, Deputy Minister
Ontario Ministry of the Environment

Moderator: Gerry Ronan, Director, Laboratory Services
Branch, Ministry of the Environment

Panel Members:

Dr. Stephen H. Safe, Texas A & M University
Ms Helle Tosine, Ministry of the Environment
Ms Joanna Kidd, Pollution Probe
Mr. David Hay, Environment Canada
Dr. W.Howard Rapson, University of Toronto
Dr. Jake Ryan, Health and Welfare Canada
Dr. Brendan Birmingham, Ministry of the Environment

Proceedings of a seminar conducted in the Auditorium of the Ministry of the Environment Laboratories, 125 Resources Rd., Rexdale, Ontario, on Wednesday, October 22, 1986

Edited by Adam Socha
Hazardous Contaminants
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Province of Ontario
Ministry of the Environment
1987

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Toronto, Ontario
October 22,1986
9:00 a.m.

I INTRODUCTORY REMARKS:

R. McLeod:

It is a real pleasure for me to be here today to briefly introduce this discussion because I think many of us in the Ministry believe quite strongly that this kind of discussion is not only long overdue, but is one which hopefully will help us considerably in confronting and understanding what many people, certainly in this province, believe to be one of Ontario's very serious environmental problems.

During the last few years dioxins have become a continual source of concern. They have appeared, and I use that word advisedly, in our air, in our water, in our food and alarming stories about them have appeared in the media on a regular basis. We have seen stories of dioxins draining from chemical waste dumps into our rivers and lakes, dioxins accumulating in fish and other aquatic creatures, dioxins pouring into the air to be deposited into the soil and absorbed into food. We have almost begun to talk about them in such hushed tones that it is a little bit like talking about cancer, death or some kind of mysterious plague that many who are reading and some who are talking do not fully understand.

The fear that has been generated by some of the dramatic publicity may well have served a useful purpose in focusing attention on the subject. It may also have tended to cloud the issues from time to time.

In our view it is time to at least try to put an end to some of the confusion and some of the mixed messages, to give the issues a thorough going over and attempt to arrive at a balanced perspective.

We obviously should not minimize the problem or the task. The problem is real and it is serious, but until we define the problem, the task will at best be unclear and our chance of finding sensible and effective solutions will not be very high.

The Ministry, we believe, has already taken several steps in this direction. Our first priority has been to both investigate the environment for dioxins and to participate in the setting of standards in order to discover the true extent of the problem. This has involved some very extensive monitoring and analysis. We have been examining drinking water, air, soil and food. We have tracked dioxins to their sources in chemical waste disposal and incineration. During the course of these scientific studies we have developed many techniques for very precise evaluation and analysis. We have embarked on a new approach to standard setting and produced a scientific criteria document. This document provides the basis to ensure that total exposure from both inhalation and ingestion is kept at or below acceptable levels. It has formed the basis for the development of Canadian National objectives for dioxins and that is an enterprise in which we are participating with our sister provinces and the federal government, at, I hope, full speed.

A second priority is appropriate legislation, regulation and enforcement. We believe that we are also leading the way towards the kind of regulatory reform that comes to grips with the problem. With the information gained from our research we have been able to make some significant changes in Ontario's environmental legislation and regulation. We have revitalized the established regulations and created some much needed new ones. With MISA, our Municipal/Industrial Strategy for Abatement program and proposed revisions to Regulation 308, we have initiated more sophisticated monitoring programs and set the stage for more demanding standards for evaluating emission control. We have also strengthened the enforcement of these laws, serving notice on polluters that we intend to keep pushing abatement activities until dioxins are virtually eliminated from the environment.

A third but overriding priority is to live up to our commitment to see that the public is well informed about this whole issue. The public must understand what is going on and what we are trying to do about it. A better informed public will help us form better policy and get on with the job of reducing risk and protecting the environment.

The Government of Ontario is determined to conduct its operations in as open a manner as possible, making all of our information accessible to the public. This does not just mean opening the books and saying "there you are" and leaving people to struggle through obscure scientific data. It means being prepared to take the responsibility to attempt to translate scientific equations into a language that everyone can understand, while at the same time, of course, making the scientific data available to those who wish to use it as source material.

Today's seminar, and indeed the whole week here with the open house, are part of this effort to communicate environmental information clearly and as early as possible. It is particularly gratifying for me to see this event take place because I felt in the year I have been with the Ministry of the Environment that the dioxin issue was in urgent need of a good airing. We are very fortunate in having a panel of experts here this morning who we think can do just that. Working on the principle that by encouraging diverse perspectives we will gain a balanced overview, we have brought together some people with very different viewpoints.

Our panel includes research scientists, academics and environmental public interest advocates. It is my privilege to take a few more minutes of your time to introduce them to you, although you will hear them somewhat later in the morning.

First from the Ministry of the Environment we have Helle Tosine. Helle has worked for 14 years in the field of environmental analytical chemistry. She established our trace organic laboratory. She takes part in international scientific activities relating to dioxins and has published a number of papers on the subject.

Secondly, from the Ministry, we have Dr. Brendan Birmingham from the Ministry's Hazardous Contaminants Coordination Branch. As a research associate at York University he specialized in investigating the effects of pesticides upon the environment and with the Ministry he has helped to evaluate the risks of many hazardous chemicals including dioxins and dibenzofurans.

Joanna Kidd from Pollution Probe, a B.Sc. from the University of Toronto, has authored a book on municipal waste incineration and has spent a number of years conducting epidemiological studies on cancer. As a representative from a major environmental advocacy group she will be able to provide us with a public perspective of dioxins which of course is independent of the views of the public servants in the federal and provincial ministries.

David Hay graduated as a chemical engineer from the University of Waterloo and is now the chief of Environment Canada's Urban Activities Division in their Industrial Programs Branch. His department is involved in a major program of research into air and water emissions and the study is developing a data base which will identify optimum design and operating standards and define appropriate control technologies.

From Health and Welfare Canada we have Dr. Jake Ryan whose laboratory analyzes dioxins in food and in environmental samples. As a research scientist, Dr. Ryan has developed many new techniques for measuring dioxins and dibenzofurans in biological tissues. His work has received considerable international attention.

Dr. Howard Rapson is a renowned professor of chemical engineering at the University of Toronto and also president of the Chemical Institute of Canada. He brings to our panel years of experience as a research chemist in the pulp and paper industry where he was responsible for some major improvements in processing technology and pollution control.

The panel will be moderated by none other than our own Gerry Ronan, Director of this facility. He is a person who in our view has sufficient knowledge and grit to provide the appropriate levels of freedom for and control of our respective panel members during their presentations later this morning.

My final task and my special pleasure is to introduce our keynote speaker today, Dr. Stephen Safe. Stephen comes to us from A & M University in Texas where he is a Professor of Toxicology in the College of Veterinary Medicine. He is no stranger to Ontario having received his training at that eminent institution in Kingston, Queen's University, and he went on from there to study at Oxford. He has more than 200 articles published in scientific journals and he is a highly respected authority in the fields of biochemistry and toxicology and has received several international awards for his work. He specializes in studying the biochemical toxicology of environmental pollutants such as pesticides, PCBs, dioxins and dibenzofurans. In his talk this morning he is going to concentrate on dioxins and what they are and what they do. If anyone can de-mystify and explain this subject thoroughly, Dr. Stephen Safe can do so. His abilities in this area have led both the U.S. and Canadian governments to request his services as a scientific advisor and now we too have an opportunity to make good use of his expertise and the special knowledge of the members of this panel.

It is an opportunity I am sure will prove fruitful to all of us. Please welcome Dr. Safe.

II KEYNOTE ADDRESS: DIOXINS: WHAT ARE THEY AND WHAT DO THEY DO?

S.H. Safe

DR. SAFE: What I would like to do this morning is talk to you primarily about two different classes of related chemicals, namely, the polychlorinated dibenzodioxins with the acronym PCDDs, and we will call them dioxins, and polychlorinated dibenzofurans or PCDFs, and we will call them furans or dibenzofurans.

These particular chemicals are members of a class of chemical pollutants called halogenated aromatics. The dioxins and dibenzofurans are not primary industrial products but are by-products which are present during the formation of chemicals and which are formed during incineration.

This whole class of halogenated aromatics enters the environment via a number of different routes. For example, pesticides are sprayed and industrial chemicals are spilled and accidentally introduced into the environment. They leak from dump sites and they are taken up into the environment and then they enter the biota. One of the problems we have with this group of chemicals is their peculiar chemical properties. They are halogenated and they are aromatic. That means they are fairly stable chemicals and they are also very fat soluble. So, when they enter the environment they are stable and persistent and are transported through the environment. Because they are fat soluble they ultimately bioaccumulate in the biota, including fish, wildlife and humans. This is just a summary of some recent Canadian data showing you the kinds of chemicals that are there and putting the chemicals of interest in this particular talk into perspective.

The major chemicals are: DDT, a pesticide, its metabolites are present in the highest levels, i.e. parts per million; PCBs, which everyone hears about particularly in Ontario are also a major organochlorine or organohalogen pollutant, and other minor pollutants include the insecticides lindane and hexachlorobenzene. Finally, low parts per trillion levels of the dioxins and dibenzofurans have been identified in fish, wildlife and humans. As you will note, their concentrations are much less than the PCBs, DDT, etc. and I want to address this point a little bit later.

This is a capsule comment or summary on the dibenzofurans: they are aromatic molecules substituted with chlorine. Production: nobody produces them on purpose, they are accidentally produced in the synthesis of a number of industrial products including PCBs, and that is fairly important. In addition, furans are also by-products formed during the combustion of organic materials.

Exposure: Primarily what I am going to address today is human exposure. We are going to be concerned with our own health. People are exposed to dibenzofurans occupationally, accidentally, and environmentally. Of course people occupationally and accidentally exposed are exposed to much higher levels. In order to estimate what the effects of these chemicals are, we sometimes have to look at and see what happens to individuals exposed to high levels and then extrapolate to what might happen with low level environmental exposure.

Gas chromatograms of the dibenzofuran impurities in commercial products show that PCDFs are complex mixtures. The dibenzofurans are present in multiple forms and, as you will see a bit later, only very few of these compounds are toxic. Many of them are relatively non-toxic, and in fact, some of them will actually protect you from the toxic effects of the more toxic dibenzofurans.

In addition, dibenzofurans, as I mentioned previously, are formed via incineration. They are also formed in fairly high concentrations during PCB fires, and there are a number of examples of PCB fires including an office building in Binghampton which has been abandoned for several years because of a PCB fire which formed highly toxic or potentially toxic dibenzofurans.

Analysis of fly ash from municipal incinerators shows that the dibenzofuran content of combustion products is highly complex, not composed of just a single compound. This has been repeated by many groups including the laboratories of the Ontario Ministry of the Environment.

Again, looking at polychlorinated dibenzofurans or dibenzofurans in the environment: in the Hudson River, we had a particular spectrum of dibenzofurans. These are probably due to the contamination of the Hudson River by PCBs, which contain dibenzofurans as by-products. The Baltic seals also contained much lower levels of dibenzofurans and again in both cases there are multiple dibenzofurans present in these analytical extracts from the environment.

Now, most people don't hear that much about dibenzofurans, dioxins are the buzzword, but they are both equally important and almost if not equally as toxic and so we have to consider them in tandem. Again, dioxins are not produced as a product to sell unless you are selling analytical standards. They are by-products formed in the synthesis of a number of very useful industrial chemicals including chlorinated phenols and chlorinated phenol-derived compounds such as some of the herbicides like 2,4,5-T or Agent Orange. In addition, these dioxins are by-products of organic combustion.

Human exposure, occupational: There have been quite a few accidental poisonings -- "accidental" is its own category and "occupational" exposure usually involves workers who make and handle these products.

Environmental: We know now we are environmentally exposed because most people contain very low parts per trillion residues of these highly toxic chemicals. We've seen newspaper headings such as "Ottawa Acts to Quell Fear in Dioxin Find" and "Lake Ontario Fish near Dangerous Dioxin

Levels". Times Beach is now a ghost town because chlorinated dioxin contaminated material was spread there and the levels were fairly high and deemed to be unsafe for human habitation. The town is now abandoned and probably will remain abandoned because of relatively low levels of potentially toxic dioxin products.

In the late 1970's dioxins were a problem for a number of chemical companies, and Dow Chemical which makes materials that have dioxins as by-products promulgated a theory that dioxins are products from all types of combustion. They are, but nevertheless a recent study by Hites and his co-workers showed that if you examine core sediments in certain lakes and rivers there is a good parallel with the increase in dioxin and furan levels with the increase in the production of industrial chlorinated aromatic compounds. It would appear that although small levels of dioxins form during combustion, most of these compounds are formed during combustion of chlorinated aromatics and by other processes involved in the production of chlorinated aromatic and industrial chemicals.

A dioxin profile from a municipal incinerator flyash extract reveals that it is a highly complex mixture -- it is not a single compound and only a selected number of the compounds in this mixture are toxic. Many of them are only moderately toxic and some of them are non-toxic and some of them actually protect you for the effects of dioxins. This is truly a complex mix of chemicals.

Recent data on dioxins, furans, and PCB residues in birds in the Great Lakes shows us that we have parts per trillion levels of dioxins and furans and parts per million levels of PCBs in different species.

There are five to six orders of magnitude, almost 100,000 to one million times difference in the concentrations of dioxins plus dibenzofurans and PCBs and again I want to refer to this ratio a bit later because we have to be concerned with it, we are contaminated with both sets of chemicals.

What about the toxicity in humans and animals? Hazard assessment from a human point of view is complicated, and I think I have previously alluded to this fact. We are not exposed primarily to a single compound but to mixtures, and of course these are very difficult to quantitate, it is very difficult to find out which particular components are in the mixtures. Then, once you find out what is in the mixtures, we really don't know all that much about the toxicities of the individual components.

Finally, the interactive effects of dioxins and dibenzofurans with themselves and, for example, with PCBs, have not been intensively studied and this might be very significant. There might be some significant interactive effects, but we want to begin to at least understand this possibility and perhaps understand some of the facts which are coming to light.

It turns out that dioxins, dibenzofurans and, at very high doses, PCBs, cause a number of common toxic responses, including a wasting syndrome, a lot of skin problems (typical in humans), problems with the lymphoid glands, immunotoxic problems, a liver disease called porphyria, reproductive problems and a specific reproduction problem called teratogenicity. They are also thought to be involved in carcinogenesis or cancer in animals. But there are a lot of problems and complications here and I think we should be aware of them.

I want to look at a number of factors which effect toxicity, for example species variability and response differences in four species: rat, mouse, guinea pig and humans. Dioxin and dibenzofuran exposure in humans results in skin problems (chloracne). However, guinea pigs which are very sensitive to these compounds have no skin problems.

We don't know if dioxins are teratogenic in humans, but with guinea pigs and rats, dioxins are not teratogenic. In some strains of mice, these compounds are highly teratogenic, but there are various response differences in different species.

There is another problem, namely the multiplicity or large number of possible individual dioxins and furans. There are 135 possible furans of different activities and this is why the analytical problem is difficult. They must be identified and quantitated and their relative toxic potencies must be known to make any rational risk assessments.

Another problem for risk assessment involves metabolism and pharmacokinetics. The gas chromatogram of the PCDFs found in the Yusho oil (responsible for a poisoning incident in Japan) are highly complex. The PCDF pattern in human extracts is much simpler and only 5-7 major congeners are present.

There are 75 total dioxins and only six of them are highly toxic, four are moderately toxic and 65 are probably almost non-toxic. Many of these might in fact protect against a highly toxic compound and we have good solid experimental evidence on that which I won't present today. With dibenzofurans it is the same problem. About eight of them are highly toxic, and I would estimate that 10 furans are moderately toxic and 117 of them are relatively non-toxic, and in fact some of them which we have tested are anti-dioxins, that is, they protect against dioxin toxicity.

The most highly toxic dioxin is 2,3,7,8-TCDD, the one everyone talks about, but not all dioxins of course are equally toxic and I have alluded to that many times. In fact what I want to illustrate is how the moving of a single chlorine by one position can change activity or toxicity ten thousand-fold. What I would like to do is show you what happens if you just take the chlorine at C-2 and place it at C-1. Here we have the highly toxic

2,3,7,8-TCDD and I am looking at relative toxicity in terms of three typical responses, enzyme response, immunotoxicity (an impairment of the immune responses) and body weight loss. With that chlorine shifted one position, 2,3,7,8-TCDD is 7,500 to 25,000 times more toxic than 1,3,7,8-TCDD. You can see there is a major problem in risk assessment for these complex mixtures.

In addition are species variability and dose differences. Let's just look at one compound, the most highly toxic member of this series, 2,3,7,8-TCDD.

Species variability: The guinea pig is highly susceptible. You can kill a guinea pig at dose of 0.6-2.0 ug/kg body weight, however, the hamster and the frog are over a 1000-fold less susceptible to the lethal effects of TCDD. One of the problems is that we do not know how susceptible humans are. Are we like guinea pigs, are we like hamsters or are we in the middle? Humans are usually genetically highly variable and chances are we have groups in each area, but we don't know where humans fit in.

During the last part of my talk I would like to focus a little bit on humans. We can extrapolate with respect to environmental exposure by looking at the occupational or accidentally exposed high dose groups. The best documented exposure to dioxins and furans is in the accidental exposure of the Yusho victims in Japan and Taiwan. So, I want to look at toxicity to humans, the effects of high doses, which are best explained in the Yusho poisoning incident.

Now, briefly, this is what happened: Both in Japan and in central Taiwan some PCBs which contained very high levels of dibenzofurans leaked into some rice oil which was distributed and poisoned several thousand people. These effects have and are being documented and this is the best example of high level exposure to dioxins and furans. Recently a number of groups including my own have shown very conclusively that this disaster is a dibenzofuran disaster and not a PCB disaster.

Now, what are the toxic effects? There are several, and these include dermal toxicity (chloracne), eye effects, neurological effects, respiratory effects, liver effects and reproductive problems; a whole range of responses, many of which are observed in the animal studies and the animals in a sense have therefore been good predictors of toxicity in humans. These effects have been summarized in a number of articles. Chloracne is a very persistent acnegenic response which can only be removed or treated with sandpaper and it can last ten to fifteen years. Most of these effects disappear after the exposure has been eliminated, but they do so very slowly since the chemicals persist in the body. A major consideration is the long-term problems. It would appear that given low enough doses one can recover from the acute toxicity, but what about the long-term problems? The problem that most people look at is cancer. The cancer studies have been going on for some time, and we can look at some of the cancer studies on people exposed primarily to dioxins and furans in industrial accidents or with herbicide sprayers. These are occupationally high dose exposures since the herbicides contained dioxins and furans as by-products.

The cancer studies have been going on for various lengths of time with various numbers of cases. In some of these studies there are no excesses of any cancers at all, and these are high dose exposures. In some cases there would appear to be excesses of some cancers and people are concerned about the lymphomas and some fibrous sarcomas. They are not large excesses and since exposures here were not only to dioxins and furans but also to large doses of herbicides, one cannot directly point the finger at the dioxins and furans, although one has to say that they may be a contributing factor.

Well, what we are concerned with from a Ministry of the Environment point of view and from the people of Ontario's point of view is:

(1) what are the effects of long-term exposure to parts per trillion levels of dioxins and furans?;

(2) are there any important interactive effects? We know there are high levels of PCBs in the environment but do the PCBs and dioxins act in concert to create any extra problems from environmental exposure?

I don't think we know the answer to question number one, but I think if we extrapolate from the occupational exposure to the low dose environmental exposure, it is highly likely that the environmental effect of the low doses we appear to be exposed to have no significant effect, though that is not proven. What about the interactive effects? We know there are hundreds of thousands of times more PCBs in human tissues and we know that at very high doses PCBs act like dioxins. They are about 10^5 to 10^6 times less toxic than the most toxic dioxins but could they add together and lead to a health problem? That is something we have to address and that will really be the subject of the last part of my talk. There is Canadian data available, mainly from Jake Ryan's research, on human adipose tissue levels of dioxins and dibenzofurans in Ontario, Quebec and the Maritimes. I think we should be aware that there are parts per trillion levels of dioxins and furans in humans and when we compare the PCB levels to dioxins/furans, the ratio of PCBs to dioxins plus furans is about 3,000 to one. It can be as high as 10,000 to 50,000 to one, but it is usually in that order.

PCBs of course are almost a bigger buzzword than dioxins and furans in Ontario and again they are made industrially. PCBs have entered the ecosystem and environmentally PCBs are a disaster. However, if you look at human exposures occupationally, accidentally and environmentally the situation is quite different. If you look at the data carefully, and I have, you will come to the conclusion quite clearly that there are no acute toxic effects from environmental exposure to PCBs, and based on the occupational data, it would appear that environmental exposure to PCBs results in no adverse effects, even at the levels we see now. I think if you read the literature carefully you have to come up with that conclusion.

Now in terms of long-term effects and the role of cancer, we don't know the answer, however if you extrapolate from the high dose occupational work, we have to conclude that the long-term effects from environmental exposure to PCBs are minimal.

However, if PCBs in high doses are dioxin-like, and there are dioxins present might they add together to give human health problems? There has been a great hue and cry in the Canadian press about the human toxicity of PCBs and in my opinion, this toxic threat of PCBs is not based on scientific facts. I have to admit to contributing to the scare over PCBs, but we have obtained a lot more information in the last three or four years and I think it is very clear that environmentally they are not the highly toxic cancer-causing agents that everyone is led to believe.

Environmentally they are to be avoided, they are a disaster because they persist in the environment, but from a human health point of view their toxicity is minimal and grossly overexaggerated.

I want to close with I think some new data. We wanted to look at the interactive effects of dioxins and furans with PCBs and carried out the following experiments. We chose a number of animals and administered a moderately toxic dose of the most highly toxic dioxin, the 2,3,7,8-isomer. We used Aroclor 1254, a commercial PCB product, which, in part, resembles "environmental PCBs". We measured the effects of the PCB alone, the dioxin alone and the two in combination and tried to make the combination such that we would parallel the PCB/furan and dioxin ratios found in humans. We wanted to look at a number of key toxicities or biologic effects including the induction of a particular enzyme which is characteristically associated with these toxins. We wanted to look at immunotoxicity and teratogenicity. We wanted to look at the interactive effects, because the combination would mimic what is out there in the environment. This was a study in a strain of mice in which we looked at thymus weight. The thymus of course plays an important role in the immune response and if you can kill off the thymus you have problems.

If one administers TCDD the thymus weight is decreased significantly. That is a typical toxic effect caused by this compound and if you look at other immune responses they are also impaired. What about when you administer Aroclor 1254? When Aroclor 1254 is administered at doses several thousand times higher than that of TCDD we observed no effects. However, when you combine the two, the thymus weight was 107 per cent greater than with TCDD alone. We have carried out a number of other immune impairment responses with mixtures of dioxin and Aroclor 1254, and we find that with PCB/TCDD ratios of about 3,000 to 10,000 to one (similar to their environmental ratios) the PCBs clearly protect the animals from the toxic effects of dioxins and dibenzofurans. I am not going to tell you that we should start dumping PCBs to protect ourselves, however it is a fortuitous circumstance that PCB can act as "anti-dioxins". This is new data and I think it is very interesting and we are fortunate that that is the case.

We are also investigating the protective effects of Aroclor 1254 in a mouse teratogenicity assay in which we are looking at cleft palate. This is the highly publicized birth defect seen in mice but not seen in humans exposed to dioxins. We administered first of all corn oil to these animals and observed no effects (our controls). We administered a dose of TCDD (20 ug/kg) that gave about 60 per cent fetal cleft palate; it is a very characteristic toxic response. In a ratio of about 10,000 parts of Aroclor 1254, the commercial PCB, to one part TCDD (20 ug/kg) we can almost completely eliminate the cleft palate in these mice. So, we have again an example of an interactive effect of two of the more important chlorinated aromatics in the environment showing that at least in ratios of about 3,000 or 10,000 to one, based on animal studies the PCBs have the potential to protect us from the toxic effects of dioxins.

Thank you very much.

III ANALYZING FOR DIOXINS AND FURANS

H. Tosine

THE MODERATOR: The first speaker will be Helle Tosine and Helle will try to reduce the whole business of the analysis of dioxins and furans to simple lucid concepts to render it as understandable as possible in terms that would helpful in the later discussions, but if there are any questions you have they will be dealt with when the whole panel gets up here and can collectively solve them.

MS. TOSINE: Analysis: Analysis is that area of science that answers the question: What is in this sample and how much is in the sample? How much dioxin is in this effluent; in the emission that is coming from the stack; in the fish, this Great Lakes fish, and in this lake water sample? If there is any dioxin in any of these samples, how can we be absolutely sure?

For today's session, I am going to define analytical chemistry as the determination with confidence, utmost confidence, of what dioxins and what dibenzofurans are in samples such as the ones I show and how much is there. Today I present you with four major challenges the analytical chemist faces in the analysis of dioxins or dibenzofurans.

The first is that we need to separate all the dioxins and the dibenzofurans from the other organics or the carbon containing compounds in the sample. So, why is that so difficult? There are over four million carbon containing compounds in the world. Carbon containing compounds are referred to as organics, as you may have assumed from Dr. Safe's talk. The chemist is faced with the task of separating the perhaps thousands of organics that are found in samples such as this, all the PCBs, the fatty acids, the hydrocarbons, the phthalates, the pesticides, so we can end up with a clean sample that contains only dioxins and solvent. How do we do that?

We first remove all the organics by shaking the sample, stirring the sample or heating the sample with an organic solvent. All the organics will dissolve in that solvent. We sometimes use the solvent pentane, and benzene would be another example of an organic solvent.

We then pass the pentane through a chemical filter. It has tiny particles of sand-like material coated with a chemical and we place the sample on top and some of the organics are retained on this filter longer than others. As we pass the sample slowly through, we end up with an organic extract that contains less and less organics. The more times we pass the sample through such a chemical filter the more organics you will remove. For dioxin samples we normally pass the sample through three or four successive such chemical filters.

Since as Stephen Safe mentioned, the toxicities of the various dioxin and furan isomers differ widely, the analytical chemist is faced with a second challenge: how to separate the 75 different dioxins and 135 different furans from each other. This is not as simple as it sounds. The isomers are all structurally, physically and chemically very similar. The challenge here is how to separate things from each other that are very similar.

The analytical chemist has met this challenge partially at present by developing a long tube or column made of fused silica. It is usually about 30 or 60 metres long and the inside is .3 millimeters internal diameter. The inside is coated with a chemical and as we pass the dioxins through it is pushed through by a gas. The sample containing dioxin is pushed through the 30 or 60 metres, and some of the dioxins are retained on this column longer than others.

Essentially what is happening is the dioxins elute or come out of a column one at a time or in small groups into an instrument known as a mass spectrometer. The mass spectrometer identifies these chemicals by molecular weight. The output from the mass spectrometer is referred to as a mass chromatogram, a printout indicating the actual physical occurrence of each one of these dioxins and dibenzofurans coming out of that long column one at a time. Each signal refers to a dioxin or dibenzofuran compound. If you add up 75 and 135 there are 210 compounds we must separate and we can't do this at present. We can separate all 22 of the dioxins that contain four chlorines, but we cannot separate 210 right now.

First, the ones with four chlorines (tetra) come out of the instrument. Next we are eluting those with five chlorines (penta) then six (hexa), seven (hepta) and finally the two eight-chlorine (octa) dioxins and dibenzofurans come out at the very end.

The state-of-the-art at present, is the ability to analyze for 12 toxic dioxin and dibenzofurans. You remember from Dr. Safe's talk, he listed six dioxins and eight furans as being of the highest toxicity and we are able to separate 12 of those 14 at present.

The toxicity consideration of these isomers has dictated that the analyst meet the challenge of detecting parts per trillion or parts per quadrillion levels of dioxins and furans in environmental and human samples. In a paper Dr. Rapson lent me, he drew the analogy of a part per trillion being one ounce of vermouth in 250,000 barrels of gin. For a part per quadrillion you must multiply that another ten to the third-fold, i.e., one ounce of vermouth in 250 million barrels of gin, a staggeringly small amount.

As the chemist has to detect these lower and lower amounts of dioxin, we need larger and larger amounts of samples. The larger the sample the higher the concentrations of the interfering PCBs, the pesticides and the fatty acids, everything I named previously.

For example, when we analyze drinking water samples, we have to bring back from every water treatment plant 120 litres of water for one treatment plant sample. That is 120 litres we have to extract with an organic solvent, clean up and analyze for one water treatment plant. As these detection limits go lower and lower, the emphasis on the confidence and the reliability of the analysis increases. How do we really know that that part per quadrillion of dioxin isn't coming from the air or the dust that is in the area where we are sampling in the water treatment plant, but is really in the river water sample or the raw water sample? We have to take duplicate samples. So, instead of taking 120 litres we have to take 240 litres to be sure of the confidence. We have to include blank samples. These are samples we take from the laboratory which are absolutely clean out into the field and expose them to the environment there and bring them back to ensure that there wasn't any environmental cross-contamination at the site.

The methods of sampling become more stringent. There must not be any plastic in contact with the samples, only glass containers must be used and those glass containers must be amber glass not to let light through. All these considerations become increasingly more important as the detection limit increases.

The analysis of a normal dioxin sample takes in the order of two to three weeks depending on its complexity. When we analyze them we don't do one at a time, normally we do 13 to 15 samples at a time. We set up all those chemical filters in a laboratory all together, 13 or 15 of them, and do them at the same time. The analysis by mass spectrometer and the confirmation and the reading of the data and the writing of the report takes an additional one and a half weeks. Comparably, in other parts of my lab we can do 200 to 400 pesticide samples a month.

The need for the large data base presents the chemist with the third challenge, the challenge of how to provide very high quality, very low level data in a very short time frame. We never have enough data. We need data to determine the length of exposure, for example, from incineration: how far do the effects of incineration go? We need to take concentric circles and go out and do more and more samples. We need data to evaluate the trends over time: what is happening as compared to 1981 now in 1986? We need data to observe whether dioxins and dibenzofurans are bioaccumulating and to what extent.

The resources for this task push the analytical chemist to look for less manpower-intensive ways of providing data but still providing that high quality that a scientist can give. The ideal situation would, of course, be to go out in the field and take a soil sample, shake it up and put it into the instrument and in a few seconds the instrument produces "yes, you have dioxin, one ppt" and you go home, great. Today we can't do this yet. We are looking at ways called the triple quadruple mass spectrometer, or a mass spectrometer stuck on the other end of a mass spectrometer to give us an additional level of confidence and additional speed, but we haven't fully developed this and are looking at it right now.

We have made a great deal of progress if you look at the literature ten years ago and compare it to where we are now in the area of dioxin and dibenzofuran analysis. This is not any more the chemistry of the flask and the beaker, but it is looking at chemistry that involves really high tech instrumentation and instruments that are costing us $500,000 or $700,000 and requiring Ph.D level chemists to operate in order to get this data down to the parts per quadrillion level. We have pushed this instrumentation to the limit and we have pushed the scientists to developing new techniques in detecting much lower levels than previously ever though possible. There is still work to be done, but the progress has been really great.

I introduced the four challenges, (i) that we have to separate the dioxins from the other organics in the sample; (ii) we have to separate the 75 and 135 dioxins and furans from each other in order to detect which of the toxic ones are there; (iii) we have to look at parts per trillion and parts per quadrillion levels in order to assess the human exposure or the environmental exposure, and (iv) we need a large data base and we need it now.

I hope these four challenges I have introduced will provide the basis for the discussion and I hope you will ask me questions on that later. Thank you.

IV WHAT THE PUBLIC WANTS TO KNOW ABOUT DIOXINS

J. Kidd

THE MODERATOR: Our next speaker is Joanna Kidd from Pollution Probe.

MS. KIDD: Thank you Gerry. Good morning, it is nice to be here. It is always nice to be asked and I am glad that I am going to have a tour of the labs this afternoon because I have never been around the Resources Road Labs before.

What does the public want to know about dioxins? Well, I think the questions that they want to know or the first ones at least are on the back of the flyer that probably everyone received. I think there are seven things that the public wants to know about dioxins.

One, what are they? Two, where do they come from? Three, where do they go in the environment, what are the pathways and fate of the dioxins and furans? Four, what do they do toxicologically speaking; and the fifth question would be, is the public right now as average individuals at risk from current environmental levels in air, water or food? The sixth question might be what is the government generically speaking doing to control or remove or reduce dioxins in the environment? The seventh question might be what additionally should government be doing.

Question 1: What are they? Dr. Safe has done an extremely good job of telling you what they are. Briefly, to recap, PCBs and dioxins and furans are all chemically and toxicologically similar although there are varying potencies within the different compounds. There are 75 dioxins, 135 furans, and possibly over 200 PCBs and some of these dioxins and furans are called by some people super toxic. They can have toxic effects in labs at very low doses, while others are much less toxic.

Dr. Safe also told you we are developing the capability to begin to predict from tests and also from the structure of these compounds which ones are the most toxic, which is useful; you don't want to look at 75 plus 135 every time if you don't have to.

One of these compounds, is 2,3,7,8-tetrachlorinated dioxin, the most toxic of them. A great deal has been said about it but of the others, little or nothing at all.

2,3,7,8-TCDD in lab animals seems to be a potent cancer promoter, if not an initiator. It is a potent immunosuppressant and affects the reproductive system and the nervous system, and Dr. Safe told you all the things it can and has been shown to do in the lab. The most important thing to remember is that these compounds are persistent and lipophilic and they do not break down in the environment, and there are varying half-lives depending on the different compounds. Because they are lipophilic, they have an affinity for fatty cells like those in your and my brain, liver, body fat or blood. It follows they have an ability to bioconcentrate or increase in concentration as they move up in the food chain.

We humans as eaters of both meat and vegetables are towards the top of the food chain.

The second question, where do dioxins or furans come from? The Ministry of the Environment last year -- September, 1985 -- put out a very valuable two inch-thick scientific criteria document on dioxins and furans, which contains most of what anybody would like to know about dioxins and furans. In trying to deal with the question of where the important routes of entry into the environment were, they used something which they called "toxic equivalents" and this is a technique whereby they give 2,3,7,8-TCDD, the most toxic form, the value of one, and some of the other dioxins and furans would be one-tenth as toxic as that and would get one-tenth of the weight and some would be 1/100ths and some 1/1000ths and so on. They added up all the numbers they knew and it came to a grand total of between 41 and 89 kilograms a year that we know of and these are toxic equivalents so it is 41 -- the equivalent of 41 to 89 kilograms of 2,3,7,8-TCDD going into the environment every year and they broke them down and these were the sources: four kilograms probably come from chlorinated phenols, the trichlorophenols, pentachlorophenol production. A very tiny amount, .02 grams, probably comes from phenoxy herbicide use and those are herbicides like 2,4,5-T which of course is not used anymore, 2,4-D, and others.

PCBs. The grand total and not a yearly total, probably input about 5 kilograms of 2,3,7-8-TCDD- equivalent. Chemical wastes are another thing they looked at and we don't know how much dioxin is coming from that source and we also don't know how much is coming from home use of herbicides and wood preservatives.

That is the category of chemical products, and in the category of combustion they estimate 10 kilograms per year is coming from the three municipal solid waste incinerators we have in Ontario right now and the two sewage sludge incinerators.

Between 20 and 50 kilograms per year are coming from other combustion sources, the combustion of industrial waste and home wood burning, hospital incineration, apartment incineration, etc, etc.

The third category of sources are airborne. Just like acid rain precursors travel over airways from down the Tennessee Valley and pollute our northern lakes, so do the other chemicals floating in our air. There is some amount of dioxins floating around up there and no one really knows how much. Czuzwas and Hites, American researchers, have estimated that maybe as much as 240 kilograms per year of dioxins fall into the Great Lakes from the air. In addition, there are dioxins and furans that are coming downstream as it were from inputs upstream in the Great Lakes, somewhere between 2 and 20 kilograms per year and this includes all the Niagara River inputs and everything upstream of that.

So, a few points to note:

Combustion is by far the greatest known loading to the environment and when you add the incineration of municipal solid waste, the incineration of pathological waste at hospitals and the incineration of apartment waste in apartment incinerators, this likely makes up the greatest proportion of dioxin inputs into our environment that we know of.

An additional point to note of course is that we don't know how much is coming from the air long distances. The estimates are up to 22 kilograms per year coming from upstream in the Great Lakes and do not take into account the enormous, at this point mostly potential, threat of a metric ton of 2,3,7,8-TCDD which is estimated to be sitting in Hooker's Hyde Park Landfill in Niagara Falls, New York. If you don't know about this landfill, it sits on fractured bedrock, about 800 metres from the Niagara River, and the dioxins from that dump as predicted by our expert witnesses in a U.S. court case in 1981 were detected last year leaking out of the gorge face into the Niagara River.

Where do they go in the environment? Apparently everywhere, like PCBs which is a good analogy. Recent findings of high levels of dioxins and furans in Ontario food supports the likely carrying of airborne dioxins and furans long distances through the air, like acid rain precursors. Like acid rain precursors, people have estimated that perhaps 80% of the chemicals floating around in our air, indeed maybe 80% of the dioxins, may be coming from U.S. sources.

In water, of course, dioxins are taken up by bottom dwellers in the sediment, by breathing and in food from other aquatic life forms. They have been found infrequently in raw Lake Ontario water and a few times in treated water from the St. Clair River.

So, they are ubiquitous and they are an environmental contaminant. Dr. Ryan's work shows fairly constant levels across Canada of dioxins in human fat. Recent work in the States has refined testing capabilities so that we can begin to estimate past exposures to dioxins and furans in fatty tissues and blood levels and that is useful in terms of trying to deal with things like outstanding potential or actual health problems from the soldiers exposed to Agent Orange in Vietnam.

What do dioxins or furans do?

This of course is the $64,000 question and the bottom line is we really don't know in humans. Nobody gets exposed to just dioxins, they are always mixed in with a host of other chemicals. It is difficult after the fact to estimate exposure. Occupational exposure often gives populations that are small and the power of epidemiology to see the results in those kinds of populations is not very good.

The Ontario government held a public hearing on PCBs starting in 1984 which finished in 1985 and dioxins and furans were on the agenda because of their relationship with PCBs. The hearing panel itself hired a toxicologist, Robert Willes, to testify before that Commission and this is what he had to say about what dioxins and furans do to people:

> "Although the available epidemiological data are inadequate, it is not practical to delay an evaluation of the potential health effects from exposure to these chemicals until adequate data are available. In the face of inadequate data on their toxicity to humans, correspondingly more weight must then be given to the utilization of data obtained from various laboratory animal test systems to predict risks of adverse health effects in human populations."

And the translation is that the epidemiological data on human populations is so bad, in fact we will not expect it to get much better, that we have to extrapolate from the best information we have which is tests on lab animals.

So, that means we must assume that dioxins or furans or some of them at least are cancer promotors and affect the reproduction system, depress the immune system, etc., etc.

Are the public at risk now from environmental levels of dioxins? Briefly again, we don't know. The most recent study on levels in food done by Dr. Kate Davies of the City of Toronto Public Health Department was the first to look comprehensively at food baskets and the average amount of food that an average resident in Ontario would eat in a year, and she found high levels of dioxins and furans in milk, fruit and meat. Overall she calculated an average person would ingest 66 times the currently understood acceptable amount of dioxins and furans in the diet.

Clearly, this is very preliminary data and the study needs repeating, but Davies' findings, if they are shown to be correct, show we are already being exposed just through our diet to more dioxins and furans than are safe.

Others today or this morning will tell you more about what the government is doing to control or reduce dioxins into the environment than I will, but briefly here are some of the important things that I think are being done by both the federal government and the Ontario government:

As Ms. Tosine has told you, Ontario has made great leaps in analytical capabilities in terms of detecting dioxins. We have also improved the ability to test air emissions from sources like municipal waste incinerators where six years ago we didn't have the capability to actually test the gases and see what was going up the stack in terms of dioxins and furans. We are currently and have been testing the ability of various pollution control devices to remove dioxins from stack gases of municipal waste incinerators. We have been working on optimizing the combustion of energy from waste plants in order to reduce the creation of dioxins in the incinerator itself. The Ontario government has initiated a source testing program looking at possible dioxin emission sources into air. We have legislated or regulated maximum levels of 2,3,7,8-TCDD in products like pentachloraphenol and 2,4,5-T before it was removed from the market.

Generally in Ontario we are moving towards proper waste disposal which is important because one of the reasons we have an environmental problem with dioxins and PCBs is improper waste disposal practices in the past.

The next question then is what further should the government be doing about dioxins? I always like to pull this out, but I like to go back to something called the Expert Advisory Committee on Dioxins, the report of the Minister's expert advisory committee on dioxins, 1983 which was a committee of expert toxicologists, biochemists and epidemiologists set up by Health and Welfare and Environment Canada to advise them on dioxins and here is a quote from them:

> "Regardless of arguments about the significance of species sensitivity, the validity of risk assessments, and other uncertainties which may take years to resolve, it is quite clear that dioxins are very unpleasant things to have in our

> environment, and the less we have of them the better. It is, in fact, imperative to reduce dioxin exposure to the absolute possible minimum."

"Imperative to reduce dioxin exposure to the absolute minimum" and even if you chop off the ends of the sentence and just say it is imperative to reduce dioxin exposure, it seems to me problematic that on the one hand while expert advisors to one level of government are saying this, elsewhere in this country, in this province, municipalities and private sector proponents are lined up to build more incinerators for municipal garbage, each one of which will add to the existing load on the environment even though we don't know if we are being exposed to too many dioxins and furans through our food already.

I believe that what government should do right now in addition to what they are already doing in Ontario is to

(1) halt the building of municipal incinerators until we know we are not at risk from dioxins at environmental levels and until we know that the building of such incinerators will not put us at risk;
(2) shut down apartment incinerators as apartment incinerators are old and are not covered under our air pollution laws, they are specifically exempt. They don't operate well and they are definitely not state of the art;
(3) phase out hospital incinerators. There are some 77 hospital incinerators around this province. Most sizable hospitals have one and they burn pathological waste which is a hazardous waste and, of course, must be burned, as well as burning garbage, solid waste.

I believe the way to go is to build regional incinerators for this pathological waste, equip them with state of the art pollution control equipment and stop hospitals from burning solid waste and pathological waste in incinerators that are really not equipped to deal with it adequately.

That is all I am going to say now and I look forward to question time. Thank you.

V DIOXINS FROM INCINERATION

D. Hay

THE MODERATOR: The next speaker fortuitously is one who is an expert in the whole area of incineration and I think it follows very well from Joanna's comments to get some insight on what we are doing in Canada and Ontario with respect to dioxins from incineration sources. David Hay from Environment Canada is the next speaker.

MR. HAY: In providing you with the information she did, Joanna Kidd also covered quite a bit of the area that I wanted to review. We have heard initially about the ability to sample and to analyze and we have compiled from the records, if you will, that go back over about ten years, a list of some of the combustion sources of dioxin. I think Dr. Safe made some reference to the fact that many combustion sources will produce dioxin, not just manmade incinerators. There has been some work done on combustion of wood in several areas, and the first and third sources listed in Table 1 relate to the combustion of wood. The first was forest fires, and I guess this is somewhat of a very educated guess as to what forest fires may input into

TABLE 1

COMBUSTION SOURCES OF DIOXIN

Forest Fires	58,700 g/year
Wood--Fired Boiler	200 ng/m^3
Residential Wood Fuel Consumption	1,800 g/year
Municipal Waste Incinerator	ND* to 15,000 ng/year
Industrial Waste Incinerator	630 ng/m^3
Wire Reclamation Incinerator	440 ng/m^3
Hospital Incinerator	69 to 330 ng/m^3
Sewage Sludge Incinerator	0.5 to 53 ng/m^3
Motor Vehicle Emission	200 g/year
Cigarette Smoke	60 to 70 pg/cigarette

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*ND: not detectable

TABLE 2

MUNICIPAL SOLID WASTE
RANGE OF EMISSIONS

	Dioxins (ng/m^3)
Old Facility — Poor Operation	Up to 15,000
Old Facility — Good Operation	Up to 500
New Facility — Good Operation	ND* to 20

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*ND: not detectable

the Canadian environment on an annual basis in the form of dioxins.

Now, similar types of data project on the order of 1,800 grams per year from residential wood fuel combustion. Wood fired boilers can be slightly more efficient, generally. I do not have the information on an annual basis, but the average concentration for the data we do have is in the order of 200 nanograms per cubic metre.

Looking at the next series of dioxin sources, these are not in strict order of importance or in terms of total mass loadings, but there is some decrease of significance as one goes down the list. The next four or five items relate to incinerators, municipal and industrial waste incineration, and there is quite a wide range of emissions in terms of dioxins from these sources. For example, the combustion of municipal waste has produced emissions going all the way from non-detectable to 15,000 nanograms per cubic metre and I think there are probably numbers beyond that. I will come back to that later.

Industrial waste incinerators. The particular incinerator referred to in this list was one that was burning wood and plastic material. It was an industrial operation that produced windows, doors and products of that nature which used pre-treated wood and covered them with plastic cladding for protection against weather and what-have-you and the incineration of their waste materials produced this emission. The next category is wire reclamation incinerators which we do see some of in Canada. Dioxins from these combustion sources is in the order of 440 nanograms per cubic metre. With hospital incinerators, which Joanna has referred to earlier, there is quite a range of emissions and there is some question about the capability of these units to deal with it effectively. Typically these sources might emit 69 to 330 nanograms per normal cubic metre of PCDD.

Sewage sludge incinerators have about a two-fold order of magnitude variation in PCDD emissions. Motor vehicles are projected to emit about 200 grams per year. This is based on using the EPA data and extrapolating it to the Canadian situation. As an interesting aside, there has been some work done recently by Markland in Sweden which looked at two vehicles, one equipped with a catalytic converter and burning non-leaded fuels and the other not equipped with a catalytic converter and burning leaded fuel that had a chlorine based scavanger in it. The catalytic equipped car burning non-leaded fuel did not emit any PCDDs while the other vehicle with the leaded fuel did emit PCDDs. The numbers were in the order of 10 to 100 grams per year of 2,3,7,8-TCDD equivalents (Eadon method). Joanna made some reference as to how this equivalents concept has evolved and Brendan Birmingham will discuss it later.

Another interesting fact about that particular piece of data was that the spectrum of PCDDs, the various isomers that were present in the emissions, were almost identical to that which one observes from municipal solid waste incineration.

Finally, and last but not least, there is cigarette smoke. There has been one piece of work that we are aware of that has detected dioxins in cigarette smoke, 60 to 70 picograms per cigarette. Interestingly enough I think that only the 6,7 and 8 dioxin homologues were detected.

As I indicated earlier, this listing was not in any particular order. However, incineration being a manmade process is something which is potentially controllable. Municipal solid waste incineration is the one of greatest concern and potential impact to the environment in terms of the emissions of PCDDs and many other compounds.

Over the last 20 years there have been a number of incinerators built in North America and many other places in the world, and when we began to test them for emissions like PCDD and PCDF we discovered there was a very significant variability in the nature of the emissions and the amount of PCDD and PCDF that were coming out of them. Table 2 is somewhat of an arbitrary listing of the range of emissions that we have observed for municipal energy from waste. Included in these data sets, at least for the older facilities, is all of the built-in inaccuracies we first had in our sampling and analytical procedures. The newer information is based on our improved capability to sample and analyze.

All that notwithstanding, old facilities, poorly operated; this data set represents facilities that were built primarily in the early seventies and for one reason or another are not well maintained or operated and emit PCDD in concentrations up to 15,000 nanograms per normal cubic metre. That is fairly high and a potentially significant number.

There are a fair number of old facilities that are operated well or that have had some amount of improvement made either to the combustion system or to the emission control devices and, as a consequence, the range of PCDD emissions observed in those facilities generally are several orders of magnitude less than those from poorly operated facilities.

Now, the new systems that are being built and tested, and we are talking about systems which we will be one or two years old and do have state of the art emission control technology and are well operated, do show emissions significantly different from either of the other categories. These facilities emit PCDD in the range of non-detectable to 20 nanograms per cubic metre. I think non-detectable would generally mean less than one nanogram per normal cubic metre, or on that order.

I mentioned emissions control systems. The things we have learned from the tests we have been doing on incineration systems, energy from waste incineration systems, is that no matter how good the combustion system is, you cannot minimize the emission of PCDD and PCDF to the environment without good state of the art emission control technology. In other words, there will always be some dioxins coming out of the incinerator unless you have some form of control device on the end of it.

We at Environment Canada in cooperation with the Ontario Ministry of the Environment have conducted a fairly extensive pilot plant study on the emissions from what I would call an old medium operated facility which had about a 1,000 nanogram per cubic metre PCDD emission normally.

The pilot unit consisted of a lime scrubber and fabric filter arrangement and is generally looked upon at the present time anyway as state of the art technology for energy from waste in terms of emission controls.

The PCDD emissions during these tests ranged from non-detectable to 8 nanograms per cubic metre. There were 13 tests done; 11 of them involved the collection of samples for dioxin analysis. For 8 of those 11 samples there was no PCDD detected at all, and for the other 3 there were small amounts, 8 ng being the highest. As I recall, in only one case was there any tetra isomers.

However, an important observation from these tests in addition to the level of emission, was that the operating conditions are extremely important. This was true for acid gases, for metals as well as for organics. We found that scrubber operating temperatures less than 200°C, and preferably in the 140°C range, would be better in terms of the removal of organic substances as well as the inorganics. That is relatively significant because many systems, particularly those that are being discussed in North America have back end operating temperatures higher than that. One might expect to be able to see improvement in the operation of a facility simply by reducing the temperature of the emission control system. This is not all that difficult to do, and is a tendency we are seeing in Europe.

I think in deference to the time limit I will stop there and entertain any questions you may have at the end. Thank you.

VI CHEMICALS - BENEFITS AND RISKS

W.H. Rapson

THE MODERATOR: Our next speaker is moving into a sort of change of topic to some degree: chemicals, benefits and risks. We are privileged to have Dr. Howard Rapson with us today from the University of Toronto. Dr. Rapson.

DR. RAPSON: Thank you, Mr. Chairman. My one hour paper on benefits and risks of chemicals in the environment will be available to everybody at the table outside, so I am not going to discuss that at all.

I would like first to deal with nomenclature. We have seen already the term dioxin used. We have seen dioxins in some of the slides and we have heard that there are 75 dioxins. That is not true. There are thousands of dioxins. Not only can chlorine be substituted into the dioxin molecule but so can other elements, other organic radicals and there are lots, so we should not use this term because it is misleading to the public and I am more concerned about the public than I am about us here at this meeting.

When we mean chlorodioxins we should say so, and of those there are 75 and this has already been discussed quite well. I was very interested to read or hear -- and I heard it before -- that smoking introduces 2,3,7,8-dioxin directly into the bloodstream very quickly. It seems to me that if we want to avoid public damage by the chlorinated dioxins, the first ban ought to be on smoking! I am serious!

Very little has been said about the benefits of chemicals. "Chemicals" has become a bad word to the public through publicity, just like the word "love" has become a bad word. Yet, many chemicals are absolutely essential for you and me to live. The most essential chemical is water for we are 80 per cent water or more. We have to have oxygen, nitrogen, sodium and potassium ions to maintain the balanced composition of our blood and many other minerals we must have in food and water, calcium, magnesium, iron, zinc, copper, cobalt, phosphorous, chlorine, iodine, fluorine. Then there are the vitamins, many substances which our bodies have to have to maintain health but which we cannot synthesize ourselves and these essential chemicals must be obtained from our diet or supplementary drugs.

Then, there are 10 essential amino acids, chemicals which we must have supplied in our food, because we can't synthesize those either to produce the proteins we need for growth and the replacement of tissues. The list of chemicals essential for human life is very long and so is the list of drugs we must use to save human lives from disease and death.

What about toxicity? Nearly 500 years ago Paracelsus said and I quote: "All substances are poisonous. There is none which is not a poison. The right dose differentiates a poison and a remedy", and that is even more true today.

I would like to dwell on this because it is interesting to know you can kill yourself with water. It was in the paper recently that a man had a bad habit. Like alcohol, he was addicted to water and he died from drinking water! The other thing we are concerned about is the effect of chemicals on human health. No one has pointed out that life expectancy is increasing over the years when we have been introducing these chemicals into the environment.

When I was born in 1912, life expectancy at birth in North America was 47 years. A child born today has a life expectancy of 70 years and advances in chemistry account for much of this change. But, of course, every advance in chemistry is accompanied by benefits and risks. We tend to overlook the benefits and emphasize the risks. We must make the public aware of the benefits and the risks involved in the great advances in chemistry and we must weigh the risks against the benefits before banning any chemical.

What about life-saving chemicals? There are many. I list the top ones as ammonia for fertilization of the soil, to feed the world's population, chlorine for disinfecting water to prevent typhoid and other waterborne diseases, calcium super-phosphate for fertilizers, DDT for killing mosquitoes to avoid malaria. Incidentally I have had DDT in my liver since the forties when it was first introduced and I was wondering during Dr. Safe's talk if maybe there might be a synergistic benefit of having this in my liver or in anybody's liver. It would be interesting to examine that.

However, we have been talking about very toxic substances. The most toxic substance known to man is botulism toxin produced by a microbe, Clostridium botulinus which forms very stable spores which are very widespread, which can only grow and produce toxin in the absence of air, fortunately. The protein-like toxin is so toxic that the amount on the point of a lead pencil can kill 1,000 people. Fortunately, heat denatures the toxin and so does any acid. Only if the infected food is eaten uncooked will people be poisoned by it. There are about 50 outbreaks of botulism in North America every year.

The second most toxic substance is also a natural one. Aflatoxin B1 is produced by a fungus, Aspergillus flavus, which grows on peanuts, corn and other crops. It destroys the liver and causes cancer in minute quantities, but still very large compared with what can now be measured analytically. Of course the third most toxic substance is the 2,3,7,8-tetrachlorodibenzoparadioxin which we have been discussing.

That brings me to chemical analysis. When I was a student, an analysis using test tube beakers and burettes was laborious and time-consuming and the normal sensitivity was limited to one part in 1,000. Gravimetric analysis could go to one part in 10,000, but that was near the limit. Separation and identification of substances in very complex mixtures was a monumental task and it took several months of work.

Much of our concern about chemical pollution and particularly toxicity and mutagenicity has only developed very recently. It is a direct result of the extreme sensitivity of modern methods of analysis. Very few people understand that all of us ingest some quantity of any non-living chemical without harm. If this were not so we would all be dead long ago. For one thing we have been bombarded by radiation from outer space ever since we have evolved, over millions of years, and we are still increasing our longevity!

I maintain that there is some of every chemical man has made and nature has made present in the form of small molecules in Lake Ontario water. We see scary headlines. First it was 40 chemicals found in Lake Ontario water and then it was 400 and most recently 800, but that is utter nonsense! Somewhere between 4 and 5 million substances are in Lake Ontario water and it is just that our analytical methods can't yet detect them. Eventually they may.

I think it is very important that you, I and everybody else who understands it, try to get across to the public some concept of the significance of Avogardro's number which has no meaning to the public, but does to us who understand chemistry. It is the number of molecules in a gram molecular weight of anything and that is a very large number, 6 times 10 to the 23rd power (6×10^{23}), so large that we cannot imagine it. The ultimate in analysis, of course, would be to be able to detect one molecule and in that case we would find them all in Lake Ontario water.

So, the important thing is the dose of chemicals we ingest, and the amount that remains in our bodies. It is very significant that in our body tissues we can find the toxic substances we are talking about, and yet longevity is increasing.

So, I would summarize that the great contribution of chemicals to the advancement of mankind in a multitude of ways must be stressed; in food production, in nutrition, in health, in materials of construction, in protection of the environment, in improving the standard of living, in increasing the enjoyment of life.

At the same time we must put the risks existing and potential into proper perspective. I think that is what we are doing here. We must convince people that there is at least a very low concentration of all chemicals in normal water and food. I don't think the goal of the Deputy Minister to eliminate chlorinated dioxins from the environment is achievable. There is no way that can be achieved. We must get the concentrations as low as possible. We have been living in a sea of natural mutagens for thousands of years, yet longevity is increasing. We know today that the human DNA has self-repairing mechanisms, and if it didn't we wouldn't be here!

We must see to it that the tolerable concentration limit below which no harm is done is determined for each substance, and that manufacturing and processing maintain levels below that concentration limit. The benefits conferred by any chemical must be weighed against the risks involved in its use before banning its production, sale or use.

THE MODERATOR: I said we would hear a different perspective and a change of pace is always good. Howard Rapson had me a little bit worried, but anyone who works in a lab takes it as a kind of given that the pursuit of absolute zero is the Valhalla we will reach after a sinecure of 30 or 40 years. Raising this myth of Avogardro's number and questioning the methodologies and the fancy equipment puts a tremor through our hearts, but nevertheless it is a very valid point about analytical science really raising all kinds of spectres where we don't have the specific information or the ability to interpret the environmental health significance.

VII ARE YOU FEEDING DIOXINS TO YOUR KIDS?

J. Ryan

THE MODERATOR: The next speaker is Jake Ryan and he has the most provocative title of all and hopefully it is a rhetorical kind of statement: "Are you feeding dioxins to your kids?" Jake will let us know the latest findings in his research in that area.

DR. RYAN: Thank you. Our Moderator referred to the government experts who would drown you in data. I don't know about the first part of that statement, but I certainly hope I don't beguile you with a lot of data.

Anyhow, what I would like to say is somewhat of a follow-up to our first speaker on the analysis and use of techniques that have been available to scientists in the last little while. What is the data base then that has been established for these materials, dioxins and furans, both in food and people and what do we know today, particularly with respect to the Canadian situation?

We can break this down in the food area. Surveys have been done on fish, mostly from the Great Lakes area over a period of years, 1980-1983, both by our laboratories and the Ministry of the Environment and other groups as well. These have shown that about one-third of the fish samples from the Great Lakes have detectable levels of dioxins and furans which can be broken down as follows: 5 to 30 parts per trillion (ppt) of 2,3,7,8-TCDD, 5 to 20 ppt of 2,3,4,7,8-pentachlorodibenzofuran and 5 to 15 ppt of 2,3,7,8-tetrachlorodibenzofuran.

Interestingly in fish, again from the Great Lakes area, we find little or no higher chlorinated (hexa-, hepta-, octa-) dioxins or furans. I am not particularly sure why this is so, but that is the result. In addition, the fish which have the highest levels of these contaminants are generally the fatty fish, that is to say eels, smelt, carp, trout and other types.

A second type of food component which appears to have readily measurable amounts of these materials is in the poultry-pork area and indeed this seems to be associated with the wood preservative pentachlorophenol. A lot of poultry and pork are raised on wood shavings and very often these wood shavings are contaminated with pentachlorophenol and its accompanying dioxins and furans. The data to date suggests that about half the pentachlorophenol positive samples contain roughly 25 to

100 ppt of the higher chlorinated dioxins and furans, the hexa-, hepta- and octa- forms, which are the less toxic groups. Some of this work has been confirmed by an in-house pilot feeding study of chickens on contaminated bedding and in addition our more limited data from egg samples suggests a similar type of contamination with respect to the type of dioxin and furan which is present and also to the particular level.

These are the two major components of foods, fish and poultry and pork, which so far have an indication of containing these materials. Work on other foods which have been analyzed but not in such extensive detail as the first two categories, show, for instance, that cows' milk contains little or none of these contaminants. I think this is somewhat interesting with respect to the incineration problem because you would expect this food to be relatively high, because incineration followed by air transport could be a significant route that leads to this contamination. In addition, our data on fruit and vegetable composites taken in the Ottawa region show that there is little or no contamination of dioxins in these foods. This is in contrast, I think, to an earlier report this year of relatively high levels of these materials in fruit and vegetables; we have not been finding anything near that level of contamination as reported earlier.

Going on then from food, if you consider these materials are in food, then the next question obviously is are we getting it in our bodies? This was alluded to by earlier speakers and I can summarize some of the data which has been available on the Canadian scene. In adipose tissue it is known that there are several 2,3,7,8-chlorine substituted, persistent dioxins and furans in all Canadians. There are about 6 to 10 of these readily measurable to a ppt level and this varies from around an average of about 5 ppt for the most toxic isomer, 2,3,7,8-TCDD, and goes up to a high of around 800 ppt or close to a part per billion for the least toxic, octachlorodioxin.

Interestingly, this value for the 2,3,7,8-TCDD isomer increases with age. This is shown in various studies that have been done and the level increases between one and two picograms per decade of age, so the older you are the more of it you accumulate.

Other tissues don't contain or contain lesser amounts of these materials and indeed it appears to be associated with lipids. For instance, the amount in fat is higher than in the liver, and pretty well all other tissues, the kidney, lung, brain contain very small amounts of dioxins and furans.

Next, I want to say something about human milk. We have done some initial limited analysis using this type of food, and it indicates the levels and types of dioxins and furans in the lipid of human milk are similar to that found in human body adipose. That is to say that the amount and the types present are similar between these two types of materials, and I guess this isn't surprising since the lipid in human milk comes from the mother's adipose tissue.

The question that will arise is what does this mean so far as a health hazard goes? I think you can say that the available evidence is that in people, there is no short-term hazard otherwise we would have recognized it long ago. The more difficult question to answer is what is the long-term hazard. The levels that are in people appear to be at least 20 to 200 times less than those that are known to cause clinical effects in people involved in accidents or in occupational exposure to dioxins and furans. So, the long-term hazard of these materials is uncertain. This is being studied not only in our country but in a lot of other countries as well.

Lastly, I would like to mention briefly some of the work we and others are doing in this area. I mentioned the total diet composite samples that are being taken in supermarkets and these analyses are being pursued. There are surveys of poultry-pork again to study what effect changes in regulations on pentachlorophenol over a period of five years has had on food levels. In the survey we are beginning on human milk samples from across Canada, approximately 100 samples will be taken (some of these are available now). These will be analyzed over the next year to see what averages are in people and the variations both between individuals and regions. I think it was mentioned earlier too that there is a lot of effort in the dioxin field to analyse human blood to be able to monitor exposures rather than taking an adipose sample which is relatively difficult to obtain. You can take a blood sample, it is easier to get and it makes your sampling a lot simpler and not only ourselves but other groups are working here as well.

I think I will finish right there. Thank you very much.

VIII DEVELOPING NEW ENVIRONMENTAL STANDARDS FOR THE CONTROL OF DIOXINS

B. Birmingham

THE MODERATOR: We are now moving into our final speaker this morning, Brendan Birmingham from the Ministry of the Environment. Brendan will speak of developing new environmental standards for the control of dioxins.

DR. BIRMINGHAM: Thank you, Gerry. Having listened to all the other speakers this morning, I am wondering if I have anything left to say. However, I will plough on and repeat everything.

As is obvious from what has been said already, especially the last speaker, most Canadians are exposed to dioxins and dibenzofurans and we are exposed to a variety of different types of these chemicals and they are showing up in body tissues from people all across Canada. Present day levels of these substances in the environment are the result of many decades of industrial activity, incineration and past production and usage of chlorophenol based herbicides, wood preservatives and disinfectants. So, when we talk about controlling or regulating dioxins and dibenzofurans, we are dealing with the consequences of both past and present practices.

In 1983 Ontario decided to upgrade its scientific data base for developing standards and guidelines for these substances. To do this it was necessary to develop the scientific criteria document which I am glad to see somebody has already waved before the audience. This document, as you can see, has been completed and released and it is a state of the art review of the human and animal health effects of these compounds.

We also reviewed the sources, distribution and fate of dioxins in the Ontario environment. Exposure pathways and levels of exposure were looked at, and we proposed an umbrella maximum allowable daily intake of these substances from all sources that would ensure adequate protection of health, even after a lifetime of exposure.

This document was produced by the Hazardous Contaminants Coordination Branch using the services of Ministry experts. We obtained medical advice from the Ministry of Labour and we also had an international panel of external experts, the Ontario Scientific Advisory Committee on Dioxins and Dibenzofurans (of which Dr. Safe was a member) who reviewed and approved this document. This document has also been reviewed by the federal government and they used it as Canada's contribution to the NATO Committee on Challenges of Modern Society which has a sub-project on dioxins.

Figure 1 gives you an outline of the approach that was taken in analyzing all the scientific information that we had to go through in order to boil it down and come up with some idea of the associated risks.

FIGURE 1. RISK ANALYSIS

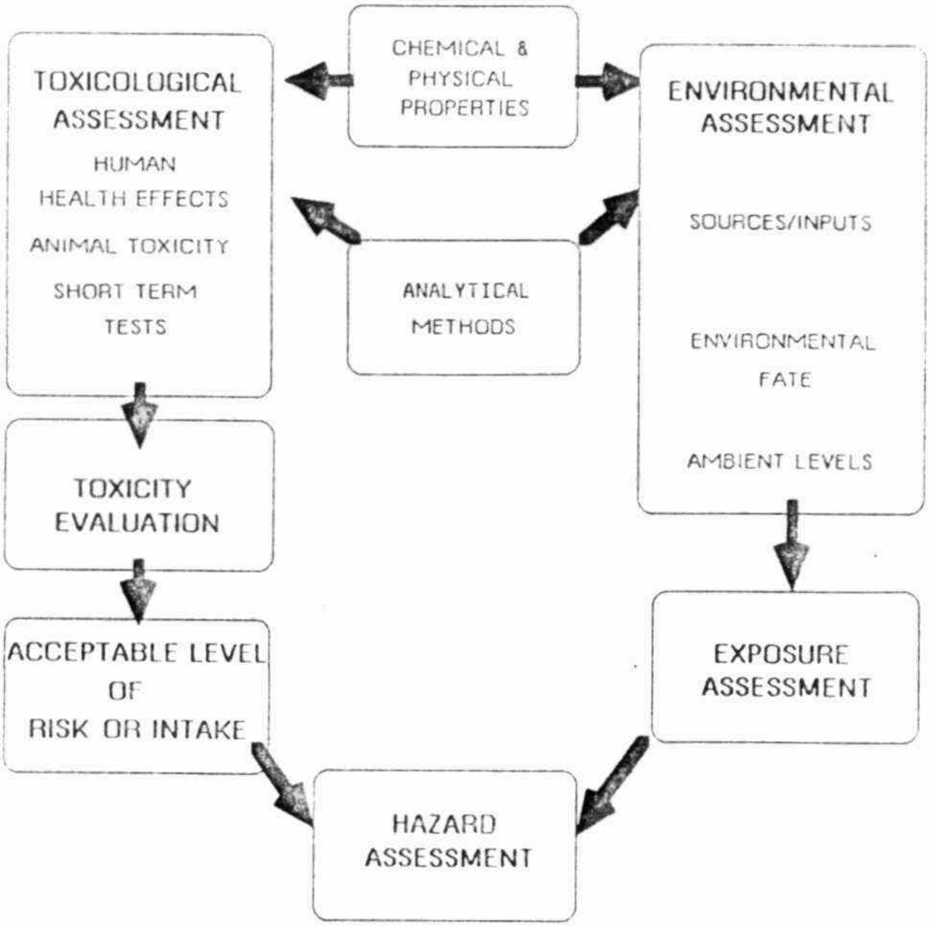


TABLE 3

ESTIMATED RELATIVE TOXICITY OF PCDD AND PCDF
ISOMERS TO 2,3,7,8-T_4CDD

Isomer Groups	Toxicity factor relative to 2,3,7,8-T_4CDD
DD	non-toxic
M_1CDD	0.0001
D_2CDD	0.001
T_3CDD	0.01
T_4CDD*	0.01
P_5CDD	0.1
H_6CCC	0.1
H_7CDD	0.01
O_8CDD	0.0001
DF	non-toxic
M_1CDF	0.0001
D_2CDF	0.0001
T_3CDF	0.01
T_4CDF	0.5
P_5CDF	0.5
H_6CDF	0.1
H_7CDF	0.01
O_8CDF	0.0001

* excluding 2,3,7,8-T_4CDD

This process involves two parallel activities one of which is a toxicological assessment and from reviewing all the available evidence on toxicology we can estimate either an acceptable level of risk or an acceptable level of intake. In parallel with this, we look at all the sources and exposure and this tells us whether or not we are exposed to a level which would cause some risk, and if there is risk associated with the exposure, it gives us an indication of how much we are going to have to control that exposure.

Now, during this process of sifting through scientific information, we encountered two major problems; one I will call the "mixture" problem and the other I will call the "ubiquity" problem. The mixture problem we had to tackle head-on because while we all know that 2,3,7,8-TCDD is the most toxic dioxin and many jurisdictions have just looked at that one, we are in fact exposed to all the others as well. The problem arises in that while we know a lot about the toxic effects of 2,3,7,8-tetrachlorodioxin, our knowledge of the toxicology of the other members of this large family is quite limited and you can see how valuable the work by people like Dr. Safe is to us since he is comparing these other substances.

Our resolution of this problem was to develop a system of toxicity equivalents so that one could mathematically convert measured levels of other dioxins and furans to a number which gives us an estimate of the toxicity of these other compounds in terms of the most toxic one, that is, 2,3,7,8-TCDD (Table 3). In fact, the maximum allowable intake that we are proposing is expressed in toxicity equivalents rather than actual weight of substance.

Figure 2 shows the other major problem that we had in analyzing risks of persistent chemicals and that is the multiple routes of human exposure. Now, if you look at our handouts, and if you have listened to the other speakers such as Dr. Rapson, you will know that we are exposed to dioxins and furans to a greater or lesser degree in all the routes of human exposure. We obviously have to account for all human exposures and this requires what is called a multi-media approach. By this, I mean an integrated assessment of exposure from air, food, water and soil. This approach was taken and an umbrella maximum allowable daily intake was estimated for all exposures.

To put our maximum allowable daily intake into context, I would like to point out that a number of worst-case exposure assessments have been developed by us and by other jurisdictions. These exposure assessments have considered the amounts of 2,3,7,8-TCDD and the equivalent amounts of other dioxins and furans that might be inhaled, ingested or absorbed using best current available estimates as to the levels of dioxins in air, food, soil and water. This includes studies by the German EPA, the Swiss government, the federal government and ourselves.

Estimates from these various exposure estimations from all

FIGURE 2

HUMAN EXPOSURE TO ENVIRONMENTAL CONTAMINANTS

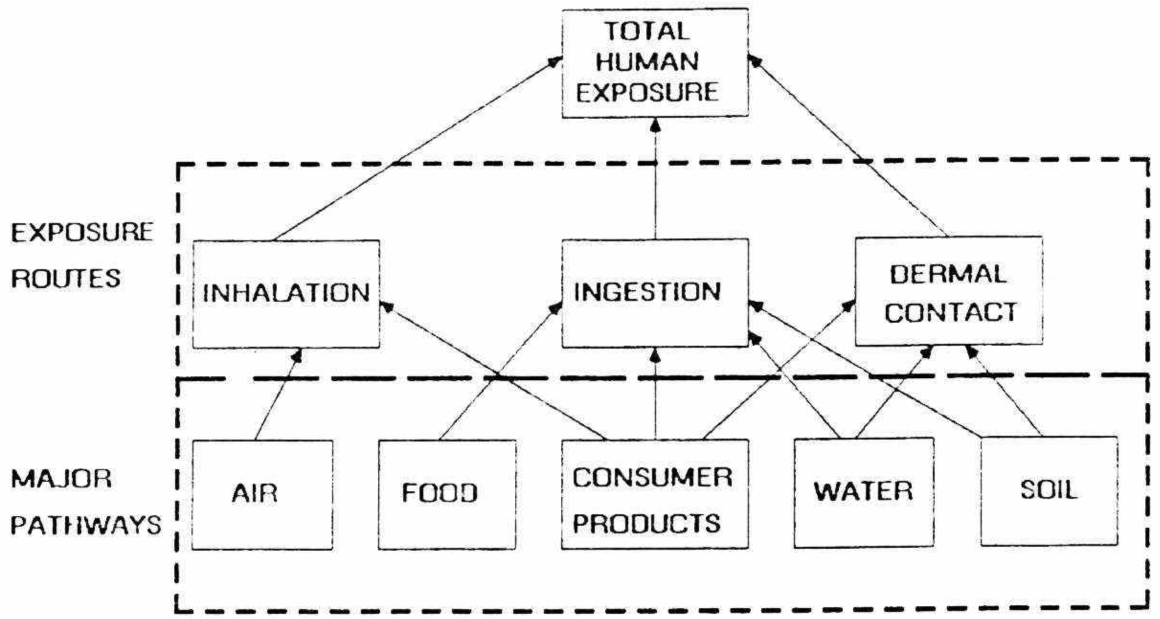
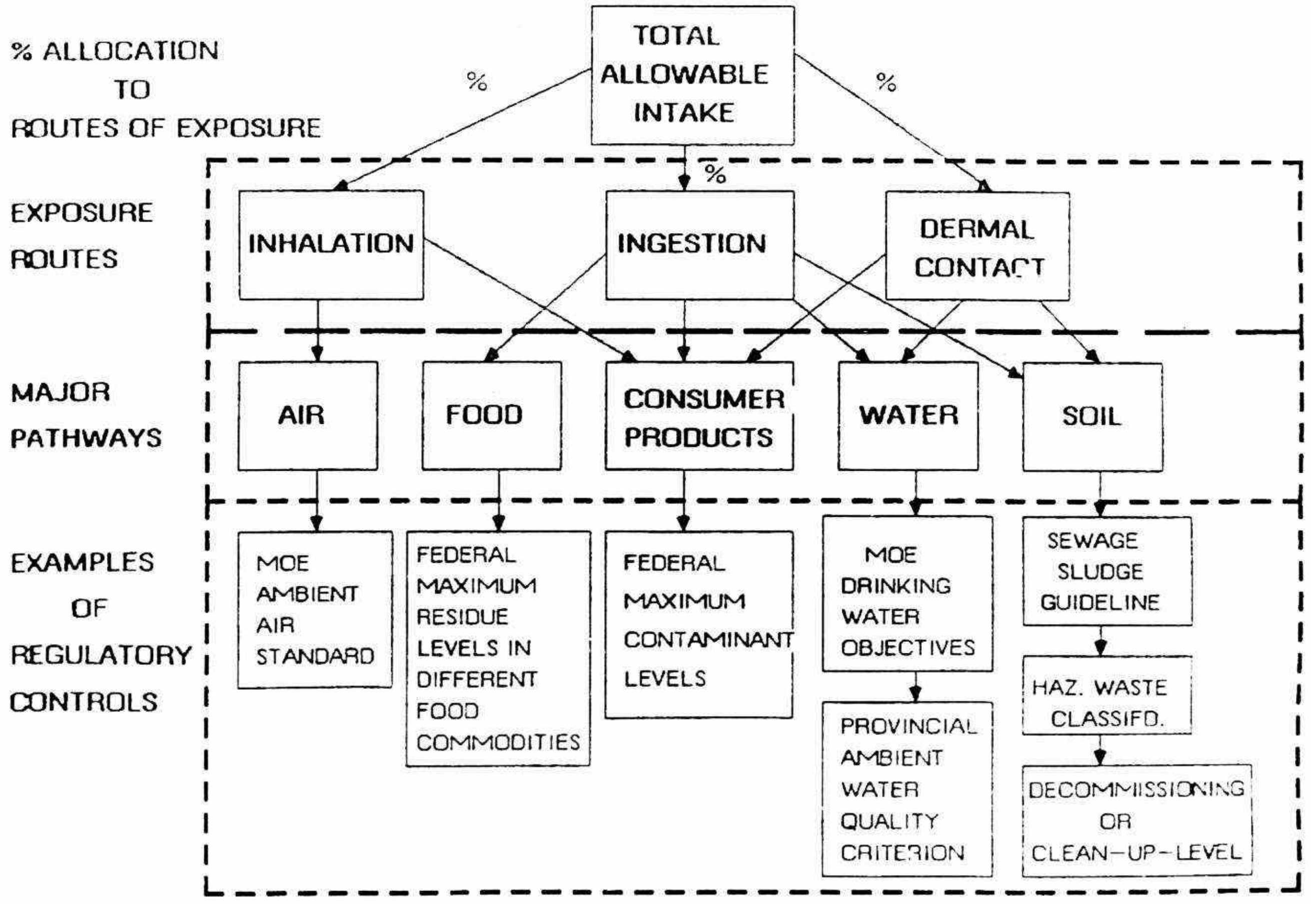


FIGURE 3

DEVELOPING REGULATORY CONTROL LEVELS


% ALLOCATION TO ROUTES OF EXPOSURE
TOTAL ALLOWABLE INTAKE
%
%
%
EXPOSURE ROUTES
INHALATION
INGESTION
DERMAL CONTACT
MAJOR PATHWAYS
AIR
FOOD
CONSUMER PRODUCTS
WATER
SOIL
EXAMPLES OF REGULATORY CONTROLS
MOE AMBIENT AIR STANDARD
FEDERAL MAXIMUM RESIDUE LEVELS IN DIFFERENT FOOD COMMODITIES
FEDERAL MAXIMUM CONTAMINANT LEVELS
MOE DRINKING WATER OBJECTIVES
PROVINCIAL AMBIENT WATER QUALITY CRITERION
SEWAGE SLUDGE GUIDELINE
HAZ. WASTE CLASSIFD.
DECOMMISSIONING OR CLEAN-UP-LEVEL

sources, if you add the air, diet, water and soil contact estimates together, range from only 1/10th of our proposed maximum allowable daily intake to about three- quarters of what we are proposing as a safe level. I think this gives us some indication of the fact that while we do know it is in our bodies, the level and exposure that we appear to be exposed to is below what we hope is a safe level.

Having developed an umbrella number, the next step is to allocate the allowable intake in such a way that exposure via the major exposure pathways is controlled by appropriate regulations and standards. As you can see in Figure 3, the allocation will be based primarily on the relative contributions of each pathway and the exposure routes are air, food, consumer products, water and soil. So, for each of these categories we have to set levels and how we divide up the umbrella number is based on our knowledge of the current ambient exposure levels and the proportion absorbed by inhalation, ingestion or dermal contact. For this we rely very heavily on our analytical staff to give us good analytical results and Helle Tosine has shown us what a difficult problem this is.

A major step in the direction of developing these multi-media guidelines has been taken by the recent establishment of a Federal-Ontario Working Group to develop national multi-media environmental standards. This group has used our criteria document to take our umbrella number and then allocate it out to air, water, soil and food as a basis for developing national environmental standards. The recommendations of this group have been submitted to the Advisory Committee on Environmental and Occupational Health.

In summary then, I think it is fair to say that Ontario is a world leader in developing dioxin standards. Since 1980 we have developed a sportfish consumption guideline in conjunction with the federal government, an ambient air guideline, a hazardous waste definition and, most recently, we have developed an interim drinking water guideline.

Other initiatives in controlling exposure of Ontario's citizens have been:

- to restrict the use of certain herbicide products;

- to maintain an extensive monitoring program to test samples of air, water, soil and fish and, most recently, we have initiated in conjunction with the Ministry of Agriculture and Food a project to analyze produce found in Ontario food stores.

Another initiative has been the formation of the Hazardous Contaminants Coordination Branch whose function is to coordinate a lot of these activities within the Ministry.

Of course, Ontario has benefited from federal programs to reduce levels and usage of dioxin-containing products, including their NITEP program that Dave Hay just explained to you is going to help us develop ways to reduce dioxins and furans in incinerator emissions.

In conclusion, I think you can see that Ontario has formed a very firm basis for protecting her citizens and environment from the health effects of dioxins and furans, and I welcome your input in continuing this process.

Thank you.

THE MODERATOR: Thank you, Brendan. That is the end of the formal presentations. The panel is going to re-arrange itself so it is facing the audience and then the audience can go on the attack and pummel them for any information they want clarified or additional information they wish to have. I think maybe while the panel is kind of getting itself in order, if you want to have just a little seventh inning stretch, without fail, within five minutes we are starting, but it might be a chance to do some exercises for your throwing arm.

--Recess--

IX PANEL DISCUSSION

THE MODERATOR: What we would like to have happen is people who wish to raise questions, if they want to direct them to one panel member, please indicate that. We would ask you, if possible, to identify yourself.

So, without further ado, I would throw this session open to the floor.

A SPEAKER: I am a biologist at Brock University. The data I have is from Dr. Harold Humphrey regarding studies carried out about the PCB levels of humans, in human serum, and he has compared two groups, those who have eaten fish from Lake Ontario and Lake Erie and Lake Michigan, and those who haven't.

He has found levels, sort of a median level of 21.4 parts per billion, and the level for those who don't eat fish from the lake is 6.6. The question for Dr. Safe is, in light of this information and in light of your observations about PCBs, what recommendations would you make about eating fish from the Great Lakes?

DR. SAFE: We have carried out animal studies and humans are not animals, but basically what we have found are that the results are based on good scientific principles, that is, that PCBs can protect us from the toxic effect of dioxins, but at high concentrations, very high concentrations, PCBs begin to act like dioxins.

So, I wouldn't recommend eating fish to protect yourself from dioxins because perhaps we don't have enough dioxins in us yet or now to need protection from. But, again because of our data there is a conundrum there. It may be in certain circumstances we may want a protective agent. I wouldn't recommend PCBs, but hopefully within the next few years we will have better protecting agents.

A SPEAKER: Thank you.

A SPEAKER: My name is Walker from Unionville High School. I would like to ask a question of Mr. Hay. You presented some data which listed a variety of concentrations and loading sources for dioxins. Can you give us a listing of priorities, a ranking for sources of dioxins or is it possible to compare concentrations or various numbers on your chart?

MR. HAY: Okay. There was an attempt to do some ranking on the Ontario document and we attempt to do that in here. There is a document Environment Canada has which also attempts to list in terms of net load to the Canadian environment. I think I mentioned that it had been identified that incineration from waste, the burning of garbage, was the No. 1 controllable input of dioxin into the environment and so in terms of doing work and in attempting to reduce or minimize dioxin emissions, that was the highest priority.

Obviously you would like to look at all of them in turn. I can provide you with a document that does give the listing and the list I had was a mixture of Canadian and U.S. data with some European information thrown in and so it was out of sequence of the listing in the reports. The report did show forest fires as the No. 1 source.

THE MODERATOR: The second row.

A SPEAKER: I am John Ralston with the Ministry of the Environment. May I respond a bit to the fish question from Brock University? I think Dr. Humphrey's work was primarily on people who ate large volumes of fish from Lake Michigan, and Lake Michigan has serious fish contaminant problems more than just PCBs, and the closest analogy I think we have in Ontario is Lake Ontario where there are elevated concentrations of PCBs, mirex, and in the past dioxin in some fish.

Lake Erie doesn't appear to be a substantial problem at all and the upper Great Lakes have pockets, but again not of the order of magnitude of Lake Ontario. How do you control the consumption of fish so that people won't be consuming levels of PCBs that exceed -- I don't want to use the words, "safe levels" -- but a reasonable level? We have put out a publication and they are out on the desk there, Guide to Eating Ontario's Sportfish, where on a species by species and lake-specific basis we provide consumption advice to people angling in Lake Ontario, the other Great Lakes, and most other popular angling lakes in the province of Ontario.

Our largest concern is mercury in most of the lakes, but in the Great Lakes particularly we have some concern over PCBs and a few other chemicals.

I would suggest people fishing in Ontario waters follow this advice and other jurisdictions around the Great Lakes in the States are developing programs similar to this program in Ontario which has been in existence for about ten years. I think this is one way of dealing with the current problem.

THE MODERATOR: Thank you, John. Was there somebody back there who had a question?

A SPEAKER: Mr. Hay, we have found information lately that shows us that dioxins coming out of the secondary chamber of an incinerator are completely decomposed and yet when we get to the stack analysis we find they have recombined.

You gave a figure of 120 to 140 degrees and the first question is, is that centigrade or Farenheit and, second, is this part of that recombination?

MR. HAY: First of all, it is centigrade or Celsius, whichever you prefer. We did a piece of work in Prince Edward Island which did show that after the high temperature combustion of the gases from the incineration process, there was very little dioxin but once the gases had passed through the boiler and was measured in the stack, there was a significant increase. This has been substantiated in other pieces of work. There was a recent test in Vienna which demonstrated the same basic phenomenon on a different type of combustion system.

So, there is something taking place in the boiler. In terms of temperature, the temperature I was referring to was the temperature that is measured in the pollution control device and it appears that that is a significant factor in minimizing the amount of all of the pollutants that are going out, not just the acid gases or metals or dioxins, but the sum total. The temperature range is not clearly defined and is probably somewhat specific to the individual incinerator technology, but it is less than 200°C certainly.

A SPEAKER: I am from the Environmental Protection Association in Mississauga. I would like to ask Mr. Hay what sort of per cent reduction would you expect to get with the lime scrubber and fabric filter?

MR. HAY: For dioxins?

A SPEAKER: For dioxins, yes.

MR. HAY: Well, our data as I indicated showed that we would enter the gas cleaning system, the scrubber or fabric filter combination, at around 1000 nanograms per cubic metre and we would come out at less than 8. So, whatever that works out to as a per cent. I understand it is 99.2.

A SPEAKER: Ross Bronson from Brampton. The New Brunswick Hydro Workers apparently were subjected to a lot of spray in the 1950's and there were articles in magazines and so forth, and I wonder if any direct analysis of their body tissues had been done or could be done and I direct that to someone who is in the analysis field?

DR. RYAN: They have a group of workers in New Brunswick called SODA, Society of Dioxin Applicators and this group contends their health has been affected by spraying phenoxy herbicides over a period of time in New Brunswick. They are in contact with the federal government about this problem, and it had been suggested about a year or two ago, that some of these people undergo fat biopsy followed by a dioxin analysis to see if in fact they had higher levels in their body with respect to what is already known for Canadians across the country. This procedure was under consideration and it never got anywhere. Now that the technique is being developed for human blood there is a better chance of this happening. The way of getting the sample will be easier in future, it is a distinct possibility, but to answer your question directly; it has not yet been done.

A SPEAKER: I would like to direct this to David Hay. Looking at your list of sources of dioxin, you have forest fires at about 60,000 grams per year and the residential wood fuel combustion at about 2,000 grams per year which is about a 30 to 1 ratio and certainly the forest fire or consumption of wood must be much greater than 30 to 1, but what accounts for the difference, have you any idea?

MR. HAY: Marvellous mathematics. The way these numbers were derived was I think to speculate on the amount of particulate material that came from a forest fire and to associate with that particular material a concentration of dioxin that had been demonstrated as a result of the burning of wood. The residential wood fuel combustion number is based on a comparable type of calculation utilizing statistics that were available on the amount of wood that Canadians burn in fireplaces and woodstoves, and the characteristics of the emissions from those devices.

Now, the fact that it came out in that particular ratio, I think you would have to query the people who actually did the work, but I have no other explanation to offer.

A SPEAKER: In response to that, I am not an expert, but I used to heat my house with an airtight woodstove and I got rid of it after a couple of years because I could smell the fumes from about two blocks away, and I suspect that the apparent difference is because an airtight woodstove burns at such a low temperature that you get a lot more garbage than you do from a forest fire which would have more complete combustion.

A SPEAKER: Harold Davidson, Councillor, Town of Port Hope, Chairman of the Advisory Committee and a chemist.

I am wondering if anybody has made any estimates of the dioxin leaking out of landfill sites from either municipal solid waste or scrap treated wood, or whatever, as compared with what can be produced with the best incinerator technology for a municipal solid waste. We have called for a moratorium on new incinerators and I am wondering if this is justified. I address that to whoever on the panel wants to handle this.

MS. KIDD: I am not aware of anyone, although many landfills have been tested. I am not aware of landfills other than those which accepted trichlorophenol wastes or herbicide wastes like the Uniroyal Landfill in Elmira, or the Hyde Park Landfill in Niagara Falls, New York that have been found to be leaching dioxins and probably the reason for that is that dioxins have an affinity for particles and they really grab on and want to stay there.

Tests done, for example, by David Hay's group at Environment Canada, where they took the precipitated flyash from an incinerator which in fact did contain high levels of dioxins and then put it through leachate tests, pretending it was sitting in a landfill and had been rained on and everything, showed that nothing leaked and the dioxins really remain bound to those particles, and that may be the reason why.

To finish that off, I think it is a real data gap that no one has done a sort of comparison of the real risks and real benefits of landfill -- of good modern landfill versus good modern energy from waste. It seems to be an enormous gap.

DR. RAPSON: In the proposal to abolish incinerators, what is to be done with the material that is not incinerated?

MS. KIDD: That sounds like it is directed to me. Dr. Rapson, it is not in the proposal to abolish incinerators, but it is a proposal not to build any more incinerators until we can be assured we are not already at risk from dioxins and the building of those incinerators won't put us at risk.

DR. RAPSON: What do you propose to do with the material that is not incinerated?

MS. KIDD: Unfortunately what you will do with it is what you are doing now, put part of it into a landfill and hopefully you are going to recycle it.

DR. RAPSON: Wouldn't it be better to put scrubbers on incinerators and continue to incinerate?

MS. KIDD: Well, it depends on whether we are already being exposed to too much. If one has already been exposed to too much, is it like a river that you write off and say this river is polluted so we will let the industries keep on dumping into it because there are no fish in it anyway? Do we make the matter worse or do we use prudence and stop and evaluate, because building an incinerator is not an easy task, they are very expensive and the economics of them are marginal at best and they are very back-end loaded. If a proponent is going to see a payback, it is not for many years down the road.

We need caution and prudence and let's make sure municipalities, and we as a society are doing the right thing before we leap into incineration as the panacea for our solid waste blues.

THE MODERATOR: David might want to comment on what is happening on the Continent in terms of any push towards the incineration option as opposed to the landfill option as a means of getting rid of waste.

MR. HAY: I don't know if there is a significant change in trend, but in England they have energy from waste and have had it for a long time and are continuing the practice and that is also true in Japan, but I would like to come back to this gentleman's question, if I may, about landfills and Joanna's comment.

I think the reason we don't see dioxin coming out of landfill leachates is because no one is looking at it for dioxins. There have been very, very few studies done with dioxins as a target chemical, but there has been a little bit of work done on the combustion of landfill gas and there has been a little bit of work done on some of the particulate material that gets into the air as a result of the dumping of the garbage and the moving of equipment and this sort of thing. I am not aware that the combustion test showed any dioxin, but I know there was dioxin in the particulate material that was sampled at the surface of the landfill and why I don't know, but I think the recommendation to gather some information in that area is a good recommendation.

THE MODERATOR: Just to clarify that comment about the lack of data. As Joanna has said, in Elmira there has been extensive monitoring for dioxin and its pathways through the aquifer, but it is prohibitive to go around looking for it at every landfill site.
We in this lab here have about a six-month backlog of fish analysis, air emissions, sediments, water samples, and we are also doing developmental work on methodology to try and get some of the bugs out of the separation problems associated with the methodology. There is a massive kind of workload associated with trying to generate the data and so it is a lower priority to take on all these landfills throughout the province, and that is the essence of the dilemma.

It is not too much help to somebody faced with an immediate decision about the two options.

A SPEAKER: I have a question. What is the natural process of removing dioxins from the environment? Are they activated or are they being metabolized or will they stay forever?

THE MODERATOR: Dr. Safe might have a go at that one.

DR. SAFE: It would appear they are slowly metabolized and slowly degraded by light and slowly degraded by microorganisms and the more chlorines or the more highly halogenated it is, usually the slower it is, but they are not here forever. They have finite half lives and they are slowly degrading.

DR. RAPSON: I have a question quite related to that. The information on forest fires is the first numbers I have seen, but I suspect they are a very important source. Furthermore, forest fires have been here ever since the forests began millions of years ago. So, therefore, there have been dioxins in the atmosphere for all time. There have been bodies of preserved explorers discovered in the Arctic recently and I wondered if testing tissues in those bodies would show that the dioxin level then was similar to what it is now, in spite of this decomposition of the dioxins with time and, if so, then I think we can stop worrying about the amounts.

THE MODERATOR: I think Dr. Rapson has just set up Jake for an Arctic trip. Do you want to respond to that?

DR. RYAN: Referring to the Arctic, actually there were some tissue samples analyzed recently from the 1860's or so, samples from Eskimos entombed in a mud iceberg type of situation, and these were analyzed. This was reported at a scientific meeting, and in fact there were no detectable levels of dioxins or furans in the tissues of these two cadavers going back over 100 years. This was evidence that dioxins had not been with us since the advent of fire as Dow Chemical contends, but are a more recent event.

DR. RAPSON: Okay, then I guess we can continue the discussion.

THE MODERATOR: Dr. Rapson has brought up an interesting point, but I think if one were to separate it into the question of ubiquitous and natural sources and then localized manmade sources that we think can control where there is a local population that may be at risk, that is where the initiatives in terms of all the retrofitting and having the most modern technology with respect to the incinerators comes in. That is where I think we have to try and focus our attention. Both points are valid as to sources, but some we can control, some with a population at risk and others are ubiquitous natural processes.

A SPEAKER: Ken Fletcher with Fletcher Associates and a question for Mr. Hay. In your chart on the sources of dioxins the question, or a similar question, has been raised, but this one pertains more to the type of dioxin. Have you broken it down into the 2,3,7,8-tetrachlorodioxin or is it just a lump of all the various dioxin compounds?

MR. HAY: The figures I was quoting were the totals and you would have to go back to the original references to figure out which of the isomers were present. I think I mentioned in cigarette smoking it was only the 6,7, and 8 homologue groups that were present.

A SPEAKER: A further quick question to Joanna Kidd. The 41 kilograms of 2,3,7,8-equivalents of tetradioxin, are those broken down or do you have those broken down into natural and manmade sources?

MS. KIDD: I gave a total of between 41 and 89 kilograms a year. Yes, they are partially broken down. There are estimates for the amount of herbicides for example, for chlorinated phenols and PCBs, for solid waste, sewage sludge incineration and other combustion sources, and for that coming in from upstream in the Great Lakes, waterborne.

A SPEAKER: What report was that? I was wondering if I could get a copy of that.

DR. BIRMINGHAM: What Joanna reported was our summary table and in fact we have something like 200 to 300 pages of data that that summary is derived from, so if you want to work back as to how we developed that summary table, you will have to be patient and read through the book. The sum of the original numbers are in there, but when you get 41 kilograms, that covers 200 pages of detailed tables.

A SPEAKER: This is produced in Ontario alone, is it?

DR. BIRMINGHAM: Some of it was estimated. We know these activities take place but we have not directly measured them so we extrapolated from other measurements.

A SPEAKER: Thank you.

A SPEAKER: Bill Schroeder of Environment Canada and I have a question for Joanna Kidd. In your talk earlier you mentioned, Joanna, that as much as 80 per cent of the chemicals in our air in Canada may be coming from sources in the United States. I would be interested in a reference to that 80 per cent figure.

MS. KIDD: That is a reference I will have to get. I took the reference from the book recently published by the Canadian Environmental Law Research Foundation called "Toxic Chemical and Oxidant Air Pollution in North America" I believe, and published by them in the United States and that is where the number comes from. It is looking at long-range transport and not local ambient.

So, if you live beside the Niagara Steel smelter, 80% of your chemicals probably do not come from the U.S.

A SPEAKER: Tony Jackson of Ontario Hydro. I would address this question primarily to Dr. Safe, but anybody else on the panel can pick it up. In light of what is currently known of the health effects of PCBs, would you care to pass an opinion on whether the attention that these materials receive as a human health hazard is deserved in light of what is known about them?

DR. SAFE: Oh, no. Quite obviously the public is misinformed in terms of their health effects. From an environmental point of view they deserve attention but certainly I think it has been way overblown in terms of human health effects.

DR. RAPSON: Maybe all the asphalt that was collected and put in barrels could be put back on the roads.

A SPEAKER: In light of that incineration talk we had earlier, what is the truth behind plasma incineration? I read recently in the Globe & Mail about plasma incineration, being 99.9997% efficient and very inexpensive, but how much truth is there in that?

MR. HAY: I haven't the foggiest idea.

DR. RYAN: I know about the plasma arc as applied to hazardous waste incineration.

A SPEAKER: They mentioned dioxin in the article.

MS. KIDD: But specifically for use with something like PCBs where you have to worry about dioxins because you create them when you incinerate PCBs. But in that case any incinerator worth its money will work at least at 99.9999% efficiency and many better than that. So it is a possible technology for hazardous waste but I haven't heard them applied to solid waste.

A SPEAKER: You are saying that when it is used on PCBs and dioxins it is not feasible in the volumes we are talking about getting here?

MS. KIDD: Oh, I don't know. It has been bench tested and in fact right now it is down in Love Canal.

A SPEAKER: They have mobile vans.

THE MODERATOR: Wilfred Ng is here who has been involved in looking at the assessment of that particular piece of equipment and perhaps he might care to elaborate further on just how effective and at what stage it is in terms of being used as a tool for the removal of these hazardous compounds.

MR. NG: I am Wilfred Ng with the Waste Management Branch of the Ministry of the Environment. In the case of the plasma arc, it was developed by Dr. Tom Barton at Kingston and the situation is that the mobile unit is in Love Canal waiting for a second phase demonstration test. It has been used for the destruction of industrial liquid waste, but it hasn't been used on a commercial basis to destroy municipal refuse. Right now, Tom Barton has entered into a joint venture with Westinghouse to market his technology and like I indicated earlier plasma arc has not been used for the gasification of municipal refuse. However, there were some bench scale or pilot scale studies in that regard and these were being conducted by a firm in Ottawa.

Since I am standing up, I would also like to follow up on some of Joanna Kidd's earlier comments. Joanna was asking or expressed some concerns about energy from waste and also asked the question, what is the government doing in those areas.

Now if you have a copy of the fact sheet and if you look at page 1 you will know what the government is doing in terms of energy from waste and in terms of other programs. Also, the Ministry recently published a criteria document for medical waste incineration. The document just came out from the print shop last week and if any of you are interested in that document, please leave your name with Gerry and I will make sure they will send a copy to you. Thank you.

DR. RAPSON: May I make a comment on the incineration problem and all these chlorinated organics which are so stable. It seems to me that the only sensible way to dispose of them is in a high temperature alkaline environment so that the alkali can take up the chlorine, because even with the plasma arc at some stage these things cool down and the free radicals re-assemble into everything possible and of course the most stable ones survive and these are the ones we are talking about. It seems to me that the only sensible place to dispose of these is in cement kilns. If people are worried they don't want it in their backyard then let's build it in no-man's land somewhere and have a cement kiln pick up all the chlorides. The operators would be pleased to have all the oil and fuel that goes with it and it won't harm the cement and it will certainly greatly improve the environment. It is beyond me why this isn't being done.

THE MODERATOR: Cement kilns, it just evokes rather unhappy memories in the Ministry which I am not about to now invoke for everybody. I think the technical soundness of that recommendation is okay, but there are hazards associated with finding a spot and what you call no-man's land is someone else's little pet piece of Valhalla or wilderness, so it is a tricky question.

DR. RAPSON: I have a tree farm and you are welcome to put it there.

THE MODERATOR: This is a very provocative gentleman.

A SPEAKER: We will be around to see you.

A SPEAKER: My name is Al Oleksiuk, Canadians for a Clean Environment of Niagara Falls and I have a question for Dr. Safe. I am a bit concerned about the possibility of reading the news headlines tomorrow that PCBs are a miracle cure or else finding somebody putting PCB pills out for people. You spoke of testing that showed that with a combination of Aroclor and PCBs there was a dramatic reduction in cleft palate occurence. Considering the information that was also made available here today, it showed a dramatic variance of reaction by different test animals to this same agent when it was introduced in the same quantities and yet the cleft palate test was built only for a single species. I am having a bit of difficulty weighing these two pieces of information and I wondered if to a layman you could possibly clarify exactly what you think it means?

DR. SAFE: When you want to antagonize an effect you must choose the right species and then choose the right dose of the toxin, in our case TCDD, and then of the antagonist and we looked at a number of doses. We chose mice because mice are the only species which are susceptible to cleft palate by dioxin. That is the simple reason for choosing that species and the doses will vary. I think we want to make it clear that antagonism by Aroclor and by many other antagonists we synthesize in our laboratory are over a particular range. I am not saying Aroclor is not toxic, it is toxic; but there is what we call a window of antagonism for certain responses in certain animals and I just gave you some examples today of some of those antagonistic effects, but hopefully there won't be an Aroclor pill.

A SPEAKER: Can you generalize from that window to other species and I think the question is how much can you generalize from your mice with cleft palate to the human public?

DR. SAFE: We can't generalize at all. We found, for example, that with Aroclor 1254, which is again a commercial PCB, one that was dumped in the environment, in some species the window of antagonism is so narrow we can't pick it up so we have to say it is not an antagonist for that particular response. For other responses in the same species we might pick it up. The reason for these differences we don't know but this is research that is really just starting out and I gave you information that is relatively new. We don't know all the answers as to the whys and wherefores of specie differences and response differences.

A SPEAKER: In connection with incinerators where at high temperatures they get the HCl or the chlorine decomposed with HCl, has any work been done on actual injection of lime into the fuel so that is there to grab onto the HCl or into the incinerator at a very hot point to grab onto to the HCl as soon as it is released?

THE MODERATOR: David, do you want to have a go at that?

MR. HAY: The only place I am aware of where they have done that and done tests on the emissions following it was in Montreal and to the best of my recollection the results did not show much difference between having lime and not having lime, but the overall emissions were so low I don't think any conclusions could be made from it.

I think in addition to that, the way the lime was added it was just mixed in with the garbage and I think if you wanted to have a significant impact from adding the lime you would try and get it more into the combustion zone.

DR. RAPSON: I think that would also be very difficult, because if you put enough lime in you would end up with that much more ash; whereas in the cement kilns the product is used, put into buildings and it stays there for hundreds of years.

DR. RYAN: I would like to comment. I think the American EPA has a procedure now of using polyethyleneglycol and KOH, an alkaline type of waste disposal and this has been found to be very effective for degrading dioxin residues at relatively low temperatures. I don't know exactly what kind of waste they have applied it to, but I know that KOH and polyethyleneglycol has been very successful.

A SPEAKER: Ron Hall. I would like to direct a question to Dave Hay, to quantify the comparison between emissions from different sources. You talk for instance about a well designed incinerator, something in the order of 10 nanograms per cubic metre of dioxins, but how does that compare? We have fairly well designed incinerators like SWARU in Hamilton, but what would that be in terms of pounds per year as composed to the emissions of dioxins from natural sources?

MR. HAY: It will take a bit of manipulation to figure out, I don't know.

DR. BIRMINGHAM: Our estimates for SWARU would be about 6 pounds per year.

A SPEAKER: As opposed to 54,000 from forest fires; I don't see the problem.

MS. KIDD: The number from forest fires is 58 kilograms per year and also I think you need to keep in mind the different kinds of dioxins created. You can't compare apples and oranges and that is why the Ministry of the Environment criteria document is useful because it does change everything to toxic equivalents so you can compare which of the sources are important, and it doesn't, for example, break out forest fires separately.

A SPEAKER: I am from the Environmental Compensation Corporation. We have heard quite a bit about sources of dioxin from forest fires. I am wondering how this might be reconciled with the slide Professor Safe showed which indicated to me anyway that dioxin in cores from the various lakes comes from the production of aromatic hydrocarbons if indeed forest fires or whatever, in my opinion, would have been the source?

DR. SAFE: Well, I wouldn't have thought so. There seems to be a good correlation between chlorinated aromatic industrial chemical production and subsequent disruption and leakage into the environment and the accumulation of these compounds in the cores. I think at least where the measurements were taken, and they were taken in a number of different areas and comparable results have been observed, that at least in terms of sediment cores the contribution of forest fire dioxins is minimal.

MS. KIDD: The most recent studies that I read by those authors showed them getting the same results essentially in Switzerland too. They used to work mostly in the Lake Superior area, but they have gone overseas and they are seeing the same things.

A SPEAKER: Gerry Copps from Markham. I would address this question to Helle Tosine. Have you done any testing of the liquid waste leaving treatment plants and discharging into Lake Ontario for dioxins and, if yes, how much is removed by sludge and how much is entering the lake?

MS. TOSINE: It is a two-part question. Have we any means or methods of analyzing the effluents from your effluent sewage treatment plants?

A SPEAKER: Yes.

MS. TOSINE: We have not done any work in that area. Environment Canada has, I know. Somebody from the Waste Management Branch would know.

A SPEAKER: If you check the fact sheet available on the desk, there is some information on testing of municipal sewage treatment plant effluents for the presence of dioxins and essentially there was only one plant where they found it at 50 ppt and that was Hamilton.

THE MODERATOR: This gets back to the earlier kind of point that was made, that it is a fantastically costly and expensive process and it is known from the work that has been done that dioxin has an affinity for particles and work done on other chemicals and surrogate parameters in waste treatment plants have indicated there is in excess of 80 per cent removal of these substances in waste treatment plants. So, the likelihood is that there are substantive removals, but we do not have a very large data base because of the sheer cost of generating that information.

A SPEAKER: If I could add to that, with the introduction of the MISA program there is a plan to look at at least 40 sewage plant effluents for the presence of dioxins and furans.

MS. TOSINE: Another point on that. We looked at three municipal incinerators in Ontario and one was a sludge burning incinerator located on the east side of Toronto at Ashbridge's Bay and we analyzed the sludge fed into the incinerator, and we couldn't find any detectable dioxins in that sludge.

A SPEAKER: I am from the University of Guelph and I have a question for Dr. Ryan. There was a paper published earlier this year in which some water samples were analyzed for dioxins from some lakes and the principle dioxin found was the octachloride. That was published in Environmental Science and Technology and the conclusion of the paper was that this showed that the principal routes of getting those dioxins into the water must have been airborne because the pattern of dioxins was similar to that found from incinerators, but in your studies of fish, you found tetras and pentas but you did not report having found the 6- through 8-chlorine compounds. Do you know if this is an analytical problem or do you think you would have come to a different conclusion about the sources of dioxins?

DR. RYAN: We don't find higher chlorinated dioxins and furans in fish, but there has been experimental work done with feeding of flyash. Fish usually don't absorb the higher chlorinated dioxins or furans but they do accumulate the lower tetra and penta chlorine-substituted ones. The actual source in the fish, I think is still open for speculation and discussion though. It is known, for instance, in Lake Ontario the level of the 2,3,7,8-TCDD is one of the highest and the most consistent in the Great Lakes and this is believed to be directly related to dump sites.

THE MODERATOR: That is a very interesting question you have raised insofar as there is not really enough data but we do find there are anomalies in different species of fish and we do not get the same patterns, but there is a very, very tiny data base and it is a question of detection and improving the methodology. I think over time there will be better cause and effect delineation of likely sources and clarification of the bioaccumulation process in fish which will explain why the patterns are different.

MS. KIDD: To add to that briefly, there does seem to be some sort of selective retention or uptake of some isomers and if you remember Dr. Safe's slide with the victims from the Yusho incident, the top slide showed the pattern of dioxins and furans, in this case to which they were exposed, and the bottom slide, the ones who remained in their livers I think it was some time afterwards.

So, there is a selective retention and it may well be structure related. The ones which are most stable which are sometimes the ones that are the most toxic are the ones that seem to be retained in the body the longest.

THE MODERATOR: At this point I think it is fitting I should blow the whistle. We ended with a question mark and there are a lot of question marks about this whole issue and I think the panel has done a great job in trying to take us through all the different compartments of the problem and the audience has played their part by asking very precise and leading questions on the issue.

Thank you very much for coming and sign up if you want to get the proceedings. Thank you.

---Applause

---Adjournment at 12:32 p.m.

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